Fish & Wildlife Division

RESOURCE STATUS AND ASSESSMENT BRANCH

# Northern Leopard Frog Reintroduction

## Year 3 (2001)

Alberta Species at Risk Report No. 42

Alberta
SUSTAINABLE RESOURCE DEVELOPMENT

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**Kris Kendell**

**Alberta Species at Risk Report No. 42**

**February 2002**

**Project Partners:**

Alberta
SUSTAINABLE RESOURCE DEVELOPMENT

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For copies of this report, contact:

Information Centre – Publications
Alberta Environment/Alberta Sustainable Resource Development
Main Floor, Great West Life Building
9920 108 Street
Edmonton, Alberta, Canada T5K 2M4

Telephone: (780) 422-2079

**OR**

Information Service
Alberta Environment/Alberta Sustainable Resource Development
#100, 3115 12 Street NE
Calgary, Alberta, Canada T2E 7J2

Telephone: (403) 297-3362

**OR**

Visit our web site at:
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The assistance of 85 volunteers, over the field season, played an integral role in the projects success in 2001. Volunteers from the Alberta Conservation Association, British Petroleum, The Calgary Zoo, Ducks Unlimited Canada, Land and Forest Service, Junior Forest Rangers, Sustainable Resource Development and the general public, donated time and energy to this project.

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My sincere apologies to anyone I have neglected.

## EXECUTIVE SUMMARY

The northern leopard frog (*Rana pipiens*) was once a common and widespread amphibian found throughout central and southern Alberta. During the late 1970s, the leopard frog experienced a dramatic decline in distribution and numbers over much of its historic range in Alberta. As a result, the leopard frog was designated as "Threatened" under Alberta's *Wildlife Act* in 1996. The Committee on the Status of Endangered Wildlife in Canada (COSEWIC) lists the prairie population of the northern leopard frog as "Special Concern" (COSEWIC 2000).

In 1998, the Alberta Fish and Wildlife Division began to explore the feasibility of reintroducing leopard frogs into formerly occupied habitats in the upper Red Deer River and North Saskatchewan River drainage basins. Large areas of unsuitable habitat limit the ability of the leopard frog to disperse back into historic parts of its range. As a result, a pilot reintroduction project for the leopard frog was initiated in 1999 at the Raven Brood Trout Station near Caroline, Alberta. The project involved the captive-rearing of leopard frogs from egg stage of development to metamorphosed frog, in two man-made outdoor ponds.

The primary objective of the project is to re-establish leopard frogs in the headwaters of the Red Deer River and the North Saskatchewan River drainages, consequently allowing natural downstream dispersal along these drainages. Over a three-year period, more than 4500 captive-reared leopard frogs have been released into historic habitat in the upper headwaters of the Red Deer River near Caroline, Alberta. In 2001, 750 young frogs were released at a pilot release site in the upper headwaters of the North Saskatchewan River near Rocky Mountain House, Alberta. All captive-reared and released leopard frogs were marked using a Visible Implant Elastomer (VIE) tagging system that allowed unique marking schemes to be used to assess the success at each release site and monitor the dispersal of released frogs.

On 19 June 2001, three previously released leopard frogs were found within the study area near Caroline, marking the first occurrence of leopard frogs in that area in nearly 50 years. At least 10 subadult and adult leopard frogs released in previous years were observed or captured within the study area in 2001 and calling activity was recorded. Evidence of the overall success of the project at the first release site may be realized in the summer of 2002, when previously released frogs reach sexual maturity, breed and successfully produce young-of-the-year frogs.

During the 2001 field season, 20 potential leopard frog release sites were investigated in the central parkland region of the province and in the upper headwaters of the Red Deer River near Caroline and the North Saskatchewan River near Rocky Mountain House. At each identified site, data were collected on the availability of breeding and summer habitat. In addition, dispersal opportunities into surrounding habitats, including the Red Deer River and North Saskatchewan River drainages, were considered.

## 1.0 INTRODUCTION

The northern leopard frog (*Rana pipiens*) is a member of the family Ranidae or 'true frogs'. Ranidae representatives can be found on all continents except Antarctica. The Genus *Rana* consists of approximately 250 species in the new world with 21 species occurring in North America, north of Mexico (Stebbins and Cohen 1995). Only three species of *Rana* occur in Alberta and the northern leopard frog is arguably the best known. The leopard frog is a large, slim frog with long hind legs that are used for powerful leaps and swimming. Mature female frogs may reach a body length of about 10 cm, while males are somewhat smaller. Background skin coloration is variable but usually ranges from various shades of green and brown; occasionally golden, blue or other morphs are described. A key diagnostic feature of the leopard frog is the presence of numerous round or oval dark spots with light borders on its back and sides. Also present, is a pair of continuous, lightly coloured ridges that extend from behind the eyes to the groin on either side of the spine (Photo 1).

Photo 1. Adult male northern leopard frog (*Rana pipiens*).

The leopard frog was previously widespread and common in much of central and southern Alberta. During the late 1970s, the leopard frog vanished over much of its historic range in Alberta. The decline of the leopard frog in Alberta is not fully understood, but it is generally believed a number of factors, acting alone or in unison, may have played a role.

Possible factors for the decline of the northern leopard frog include drought, the loss and degradation of habitat, disease and pathogens such as "red-leg" (*Aeromonas hydrophyla*) and the more recently studied chytrid fungus (*Batrachochytrium dendrobatidis*). The effects of biocides (pesticides and herbicides) and other pollutants have also been implicated. Drought may be especially significant in some localities as it can have a deleterious effect on habitat required for the successful hibernation of leopard frogs. To escape freezing temperatures, the leopard frog hibernates underwater, absorbing necessary oxygen cutaneously. Thus they are susceptible to mortality caused by anoxic aquatic conditions and the complete freezing of waterbodies. The loss of key habitat further reduces or eliminates natural dispersal routes and corridors into surrounding habitat. Negative impacts on habitat, including biocides, can result in physiological

and biological stress to the frogs at all age classes, increasing their vulnerability to naturally occurring bacteria, viruses and pathogens.

The current range of the leopard frog occurs primarily in the south and southeast portion of the province, particularly along major drainages such as the South Saskatchewan River, Oldman River, Milk River and the lower Bow River and Red Deer River. These remaining populations are isolated and fragmented, and susceptible to disturbance, disease and natural disasters. The leopard frog is currently designated as "Threatened" under Alberta's *Wildlife Act* and is extirpated from the upper headwaters of the Red Deer River drainage and from the North Saskatchewan River drainage. Remnant leopard frog populations in Alberta appear to have stabilized, but most formerly occupied areas remain uncolonized.

In 1998, the Alberta Fish and Wildlife Division began to explore the feasibility of reintroducing leopard frogs into formerly occupied habitats in the upper Red Deer River and North Saskatchewan River drainage basins. Broad areas of unsuitable habitat have limited the ability of the leopard frog to naturally disperse back into historic parts of its range. In 1999, a pilot reintroduction project for the northern leopard frog was initiated at the Raven Brood Trout Station near Caroline, Alberta (see Wendlandt and Takats 1999). The project involved the captive-rearing of leopard frogs from the egg stage of development to metamorphosed frog, in two man-made outdoor ponds.

Currently, two sites have been chosen to release captive-reared frogs. The first site is associated with the upper headwaters of the Red Deer River, near Caroline. Since 1999, three years of frog releases have occurred at this site. The second site, a pilot release site, was selected in 2001 and is located in the upper headwaters of the North Saskatchewan River near Rocky Mountain House. Frogs were released at this site for the first time in 2001. The following report details the activities and results of the 2001 field season of the Northern Leopard Frog Reintroduction Project.

## 2.0 STUDY AREA

### 2.1 Egg mass collection and frog release sites

The 2001 study area for the leopard frog project included egg mass collection locations in southern Alberta and frog release sites in the upper headwaters of the Red Deer River, near Caroline and the upper headwaters of the North Saskatchewan River, near Rocky Mountain House (Figure 1).

The Raven River release site (Release site 1) is situated near the Raven Brood Trout Station, southeast of the town of Caroline. A second pilot release site (Release site 2) is located northeast of Crimson Lake Provincial Park, near Rocky Mountain House. The 2001 egg mass collection area (referred hereafter as the draw sites) was located in the Bow City region of southern Alberta (Figure 1).

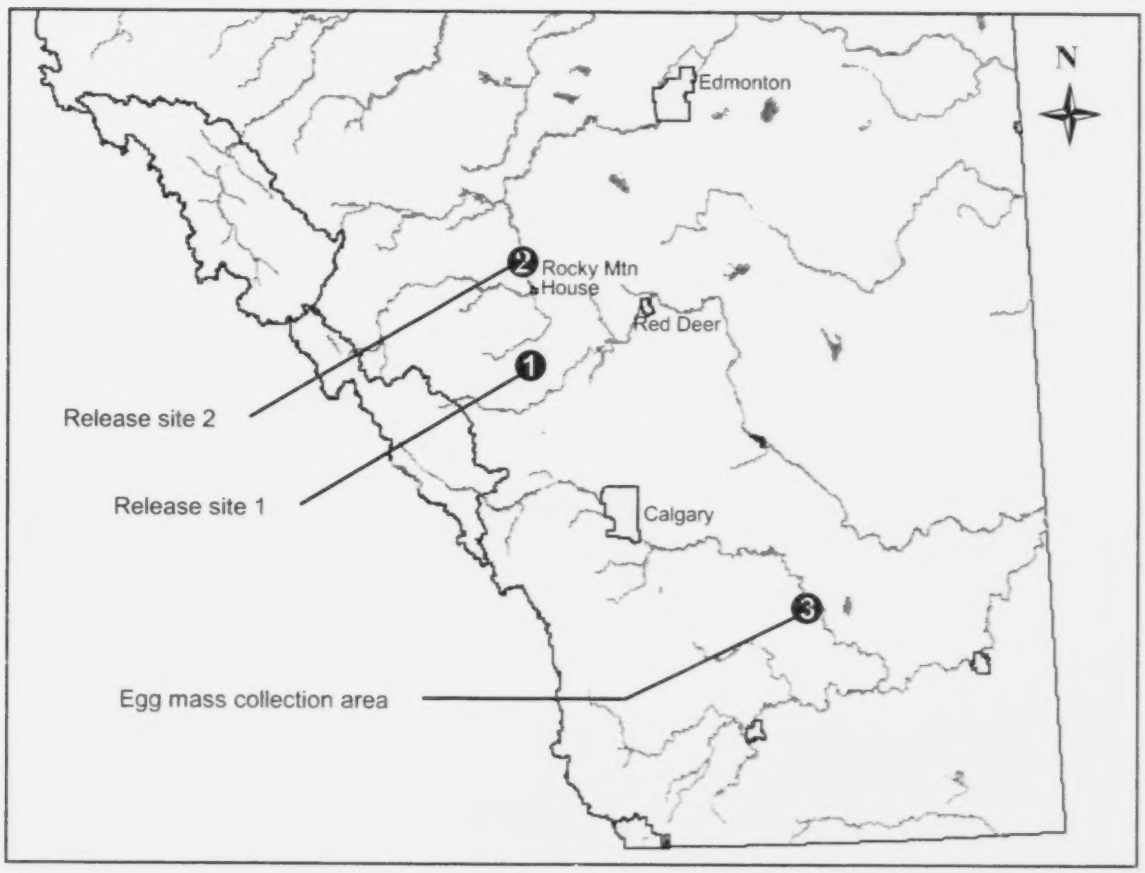



Figure 1. Alberta map depicting the original release site near Caroline (1), the 2001 pilot release site near Rocky Mountain House (2) and the area from which leopard frog egg masses were collected near Bow City (3).

## 2.2 Raven Brood Trout Station

For the third year, two large outdoor ponds (formerly used as trout raceways) at the Raven Brood Trout Station were used to rear leopard frogs from egg stage of development to fully metamorphed frogs (Photo 2). As in previous years, the artificial ponds (hereafter referred to as west or east rearing pond) offered managed access, the ability to manipulate water depths and water temperatures, and the means to confine captive-reared juvenile leopard frogs prior to being released into the wild. For a more detailed description of the rearing ponds see Kendell 2001.

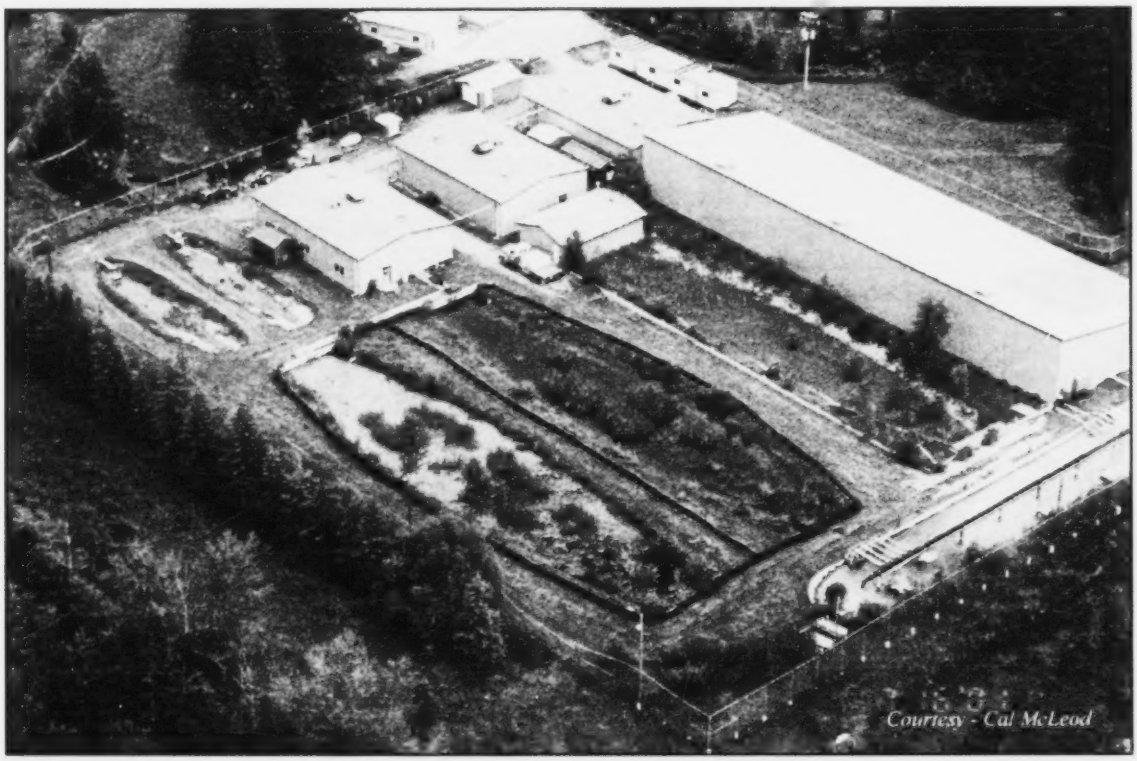



Photo 2. East and west rearing ponds at the Alberta Sustainable Resource Development, Raven Brood Trout Station, near Caroline, Alberta.

Public promotion of the reintroduction project, presentations and interpretative events were conducted at the Raven Brood Trout Station.

## 2.3 Potential release sites

Twenty potential leopard frog release sites were investigated in the central parkland of the province as well as in the upper headwaters of the Red Deer River, near Caroline and the North Saskatchewan River, near Rocky Mountain House (Appendix A, Appendix B, Figure 2).

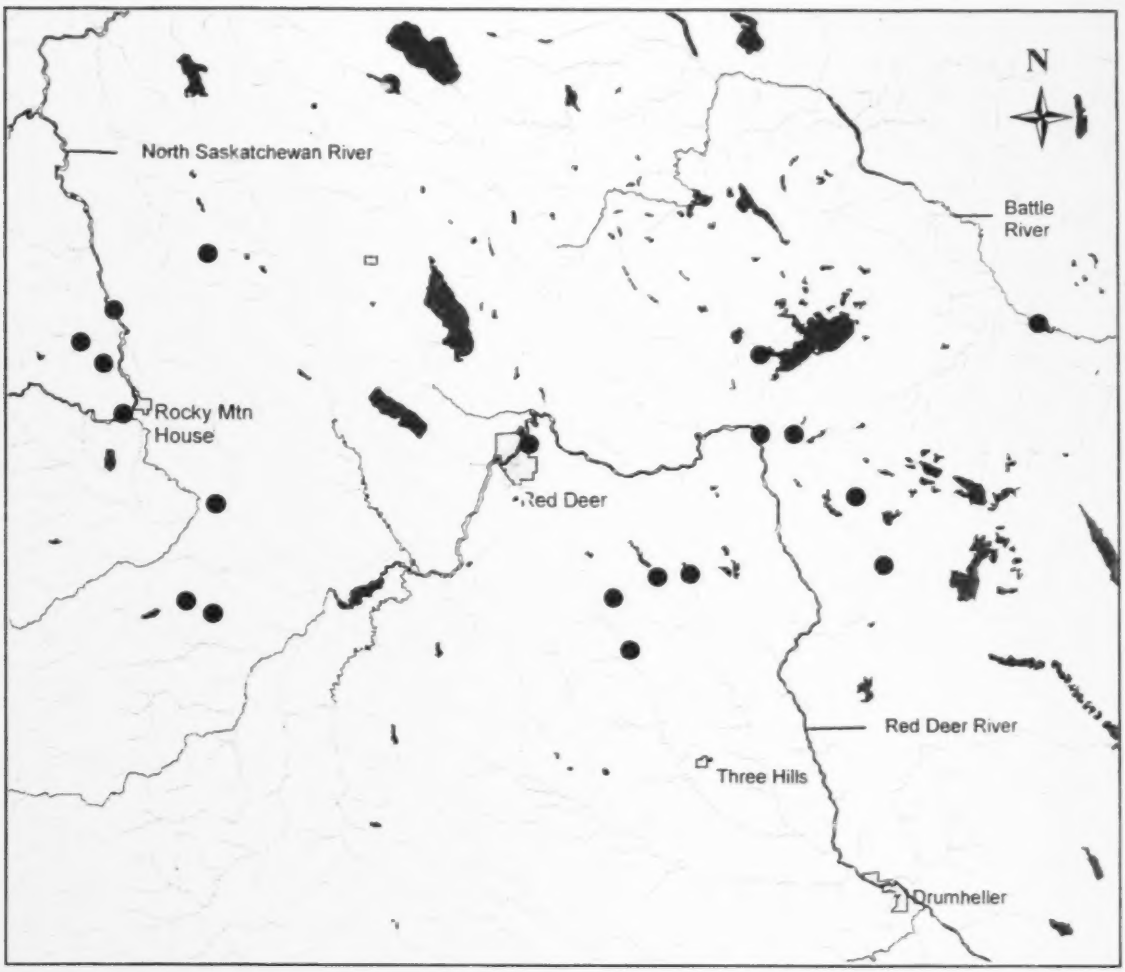



Figure 2. Central Alberta study area where potential leopard frog releases sites were investigated. The dots on the map indicate specific sites targeted for detail survey in 2001.

## 3.0 METHODS

### 3.1 Captive-rearing

#### 3.1.1 Draw sites

In late April, suitable leopard frog breeding habitat was surveyed under conditions that favoured leopard frog breeding behaviour. Optimal ambient air and water temperatures, researched in previous years, that supported frog breeding activity were used to determine the correct conditions to begin sampling for egg mass (see Kendell 2001). Conducting visual searches for egg masses in suitable breeding habitat identified breeding sites, and subsequent draw sites.

In total, six leopard frog egg masses were collected from three different draw sites near Bow City, Alberta. Efforts were made to select draw sites that were different from those used in 1999 and 2000. However, exceptionally dry conditions in the area that spring resulted in breeding habitat that was both restricted and poor in quality. Egg masses at two of the three draw sites, in 2001, were deposited in waterbodies that appeared to exhibit poor conditions for the development and growth of tadpoles, and in many cases the threat of desiccation of the egg masses was high. Therefore, egg masses observed under the above conditions were favoured for collection. At each draw site a number of water quality parameters were measured and recorded including ammonia, pH, nitrite, nitrate, phosphorous, temperature, general hardness and alkalinity (Appendix C).

### 3.1.2 Egg mass and tadpole management

Egg masses were transported from their draw sites to the rearing site in 2-litre thermoses. At the halfway point of the trip, 50% of the water in each of the thermoses was replaced with fresh water from its collection site. At the station, each egg mass and water from its thermos was transferred to a large plastic bag and floated for 20 minutes in an aquatic predator exclosure (Photo 3). In this way, transport and rearing pond water temperatures were amalgamated.

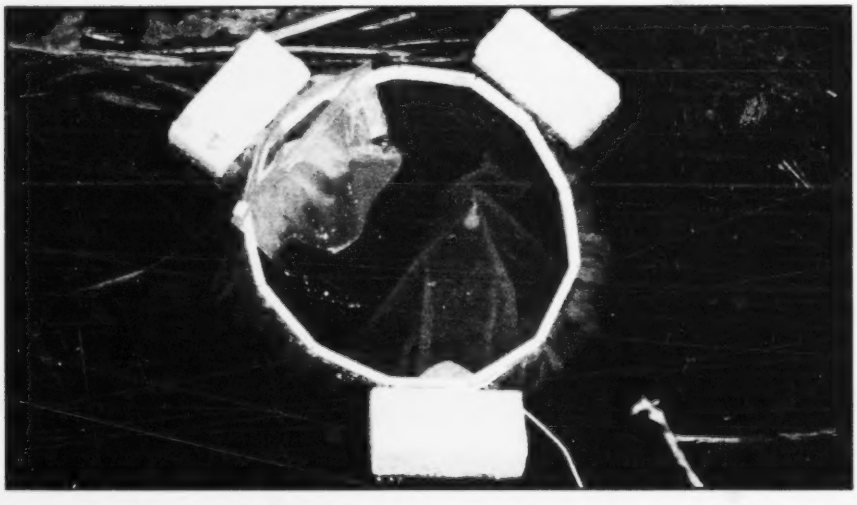


Photo 3. A leopard frog egg mass predator exclosure and egg mass (in plastic bag) in the process of been acclimatized to the water quality in the rearing pond.

Over a 20-minute period, water from the rearing pond was added to the plastic bag to reduce the stress associated with changes in water chemistry between the draw sites and the rearing ponds. Once the water in each bag was completely replaced with water from its respective pond, the egg masses were then transferred into the predator exclosure. Each of the six egg masses were separated into predator exclosures and divided equally between the east and west rearing ponds.

After complete hatch, the hatchling tadpoles were confined to the exclosures for about 16 days. At which time they were at the 20-26 stage of development based on Gosner's (1960) tadpole developmental staging system (see McDiarmid and Altig 1999). At this stage the tadpoles were

free swimming and mobile. Tadpoles from five of the six egg masses were counted and released from the exclosures into the pond that they were initially placed. A proportion of tadpoles, from one of the six egg masses, was released into the second pond to ensure an equal distribution of tadpole numbers between the two rearing ponds.

A new, larger, tadpole predator exclosures was designed and built in 2001. The new exclosure was constructed out of 1/2-inch diameter PVC conduit, 90° half-inch PVC elbows, no-see-um mesh, plastic shower rod covers, 1-inch fold-back clips and Styrofoam blocks (for floatation). The conduit was assembled into a rectangular frame measuring approximately 10 feet in length and 3 feet in width. The no-see-um mesh was held loosely to the frame using plastic shower rod covers resulting in a 45 cm deep basket within the frame. Nylon window screen, anchored to the frame with plastic shower rod covers, was used to cover the top of the exclosure to prevent predator access and the escape of tadpoles. Once assembled, the exclosures were positioned in the center of each pond and anchored to each shoreline with string to prevent beaching and uncontrolled drifting (Photo 4).

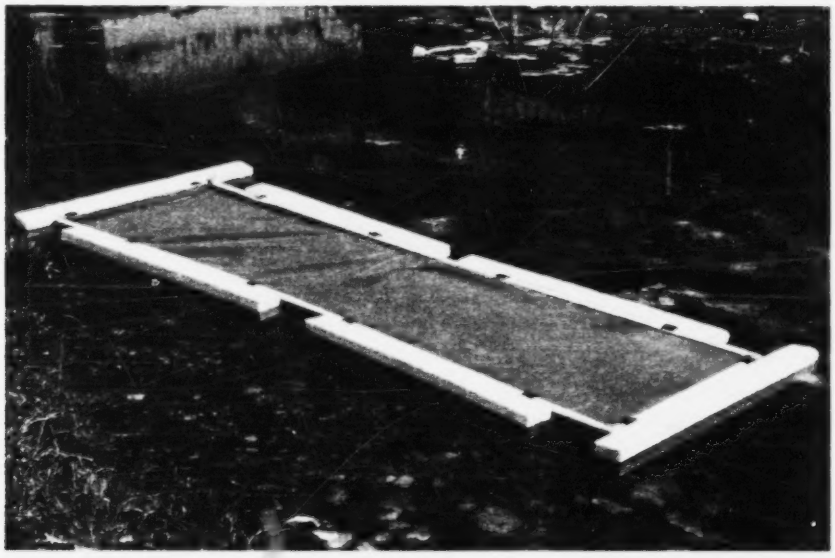


Photo 4. Large tadpole predator exclosure used in 2001 to rear tadpoles to a larger stage of development. The smaller predator exclosure design can be seen in the background.

The purpose of the larger predator exclosures were to rear the tadpoles to a larger stage of development in a protected environment, prior to being released. A proportion of hatchling tadpoles (n=1000) were selected for use in the larger exclosures. These tadpoles remained in the same pond that they were originally placed in as eggs. The tadpoles were fed algae collected from the rearing ponds and had access to algae that grew on the no-see-um mesh of the exclosures. The tadpoles were held in the larger exclosures from 28 May to 19 June. On 19 June, the tadpoles were counted and released into the ponds.

### 3.1.3 Water management

Water depths in the two rearing ponds were maintained at the maximum level allowed by the standpipes fitted on the water control gates of each pond. At this level, the volume of water in the east and west rearing pond were estimated to be 339 600 L (89 710 gallons) and 292 600 L (77 300 gallons), respectively. The estimated volume of water in both ponds did not take into account the volume displacement of the vegetation and other debris in the ponds. Water levels held at this depth help to minimize water temperature fluctuations in the ponds and promote the growth and development of the tadpoles. The water in the west rearing pond was stagnant with no in-flow or out-flow of spring water. Water lost through evaporation was replaced naturally through precipitation or, when needed, by the input of spring water from the head pond. Water levels in the east pond were also held at a constant depth, however, because of a slight leak in the water control gate a small amount of spring water was continuously added to maintain water levels in that pond.

### 3.1.4 Predator control

As in previous years, efforts were made to reduce and eliminate the effects predators on the tadpoles and young-of-the-year frogs. Identified predators from previous years include predaceous diving beetle larva (*Dytiscidae* sp.), great blue heron (*Ardea herodias*), belted kingfisher (*Ceryle alcyon*) and mink (*Mustela vison*). Tadpole and juvenile frog mortality directly associated with predators was rarely observed in 2001. The number of diving beetle larvae (*Dytiscidae* sp.) observed in the rearing ponds was significantly lower then in previous years. Odonate larvae (dragonflies and damselflies) appeared to be more common in the rearing ponds in 2001, but because of their small size and the gap limitations of their mandibles, they were not perceived as a threat. Finally, there was no observation of mink utilizing the rearing ponds in 2001.

The east rearing pond was allowed to completely freeze during the winter of 2000/2001 killing many of the aquatic invertebrate predators. The pond was also almost completely drained on 19 April 2001 for approximately 10 days to further reduce the number of aquatic predators in that pond. The west rearing pond could not be drained because a number of captive-reared leopard frogs, reared in 2000, were held over-winter there.

To discourage great blue heron from foraging in the rearing ponds, three rows of 14-gauge aluminium fence wire was erected parallel to the shore of each of the two rearing ponds. Each row of wire was separated by approximately 40 cm and the entire wire assembly (each wire) was positioned approximately 75 cm above the shore and surface of the water. The multiple rows of wire allowed for a broad coverage of up to 1.2 m over the shallow water zone and the shore of the ponds. It was believed that this physical wire barrier would discourage herons from foraging along the shore of the ponds where the tadpoles and metamorph frogs frequently occurred.

### 3.1.5 Collection of captive-reared leopard frogs

Metamorphosed frogs were collected soon after the first completely transformed frogs were observed on the shore of the rearing ponds in noticeable numbers. Nets and funnel traps were used to capture the frogs. Each funnel trap contained 1 inch of water so that the frogs would not

desiccate and the traps were left unchecked for no more than 24 hours (see Kendell (2001) for complete description of the funnel traps used). Dry and hot weather in August resulted in frogs remaining close to the edge of the ponds, thus reducing the effectiveness of the funnel traps. As a result, more volunteers were required to collect the frogs from the rearing ponds (Photo 5).

Photo 5. Volunteers help capture recently transformed leopard frogs.

At the end of August, water levels in the rearing ponds were reduced to capture the remaining leopard frogs. The weight and snout to vent length (SVL) of every tenth frog captured, for release into the wild, was measured and recorded. Physical abnormalities (i.e. missing limbs, wounds, etc.) of the young frogs handled during marking phase of the project were generally noted.

### 3.1.6 Marking

Captive-reared leopard frogs were marked using a Visible Implant Elastomer (VIE) tagging system (Northwest Marine Technology, Inc. 2001). The tagging system provided an externally visible internal identification mark (Photo 6). The mark consisted of a fluorescent elastomer agent, that when mixed with a curing agent, cured into a pliable solid within 24 hours. Using a 3/10 hypodermic syringe, this biocompatible agent was injected into the webbing between the fourth and fifth toe of the rear foot of each young frog. To reduce the activity level of the young frogs during the marking process, they were occasionally subjected to chilled (4-6 °C) spring water. Depending on the release site, different elastomer colors were used to mark the young frogs.

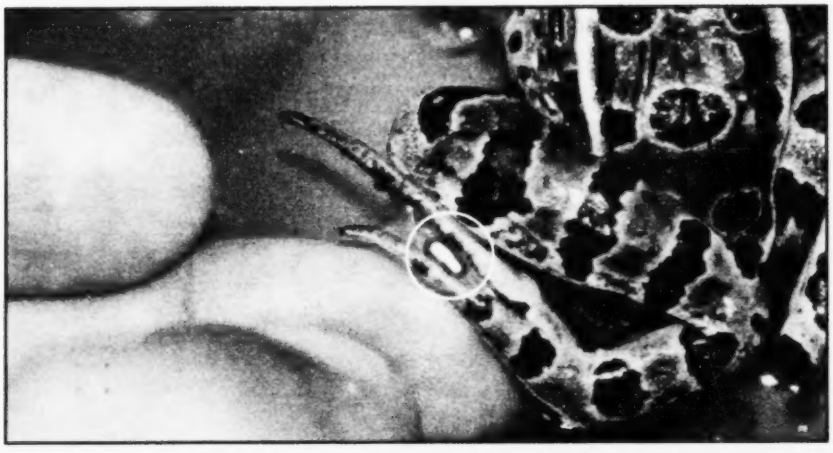


Photo 6. A subadult leopard frog captive-reared and released in 2000 showing a two year-old green elastomer tag between the fourth and fifth toe of the left hind foot (indicated with circle).

Frogs released in 2001 were all marked on the right hind foot. Frogs released at the Raven River release site were marked with red or blue elastomer, depending on the specific site released (see section 4.2.1). Frogs released at the pilot release site near Rocky Mountain House (along the North Saskatchewan River) were marked with red elastomer (see section 4.2.2). Frogs held over-winter in the west rearing ponds were marked with yellow elastomer.

### 3.2 Release (2001)

Frogs were transported to release sites using 70-litre tote bins. Moist vegetation was added to each bin and the bins had air holes for ventilation. All frogs were released directly into suitable habitat at their respective reintroduction sites. Release sites were monitored until the end of August to record the dispersal activity of released frogs.

### 3.3 Leopard frog surveys

Post-release monitoring of leopard frogs, captive-reared and released in 1999 and 2000, began in mid-April 2001. The first surveys focussed on the west rearing pond for potential surviving leopard frogs that over-wintered in 2000/2001. Additionally, surveys were conducted within the Raven River release study area beginning on 7 May for frogs released in 1999 and 2000. Eleven survey routes were established within the study area along waterways and wet areas associated with leopard frog breeding and summering habitat. Total survey times, dates and environmental conditions (wind, air temperature, precipitation and cloud cover) during the survey were recorded. All amphibian species observed during the surveys were recorded. The standardized surveys continued into June followed by less formal surveys in July and August.

### 3.4 New release site investigations

In total, 20 new potential leopard frog release sites were identified and subsequently field-tested during July 2001 (Appendix A and Appendix B). All potential release sites were limited to the

central parkland region of the province and more specifically the upper headwaters of the Red Deer River and North Saskatchewan River drainages.

Potential release sites were selected using 2 methods. The first method involved a detailed search of the Biodiversity Species Observation Database (BSOD) for historic leopard frog records that occurred in the targeted regions of interest. This method identified previously populated sites, which may have a higher probability of supporting a reintroduced frog population.

The second method involved the interview of personnel from several organizations including Alberta Sustainable Resource Development – Fish and Wildlife Division, the Alberta Conservation Association and Ducks Unlimited Canada. Individuals were briefed on leopard frog habitat requirements and asked for suggestions on a suite of potential sites based on their experience and knowledge within their respective region.

Based on initial research, all potential release sites selected for investigation were believed to posses the ecological criteria necessary to support a leopard frog population. Sites that possessed minimal disturbance or habitat degradation were favoured. Additional consideration was given to sites that possessed access that would support public promotion of the project, monitoring of released frogs and education opportunities.

## 4.0 RESULTS

### 4.1 Captive-rearing

In total, 2 983 leopard frogs were captive-reared in 2001, of which 2 833 were marked and released. Of the young frogs raised, 2 083 were released at the Raven River release site and 750 were released at the pilot release site along the North Saskatchewan River near Rocky Mountain House. A total of 150 young frogs were left in the east rearing pond to over-winter (2001/2002).

Public involvement and education were important components of the summer captive-rearing program at the Raven Brood Trout Station. In total, 85 volunteers provided assistance with the project and were involved with leopard frog surveys and the collecting, marking and release of captive-reared frogs. Volunteers included members of the general public, Ducks Unlimited Canada, The Calgary Zoo, Junior Forest Rangers, the Alberta Conservation Association (ACA) and Alberta Sustainable Resource Development (SRD.

#### 4.1.1 Tadpole and egg mass management

The small tadpole predator exclosures provided an effective management technique to safeguard the eggs and developing tadpoles from potential aquatic invertebrate predators and allowed researchers to count the hatchling tadpoles. In total, 21 036 live tadpoles were released from the six predator exclosures (Table 1).

Table 1. Numbers of living tadpoles counted in each predator exclosure 10-11 days after complete hatch, in 2001.

| Draw Site | Egg Mass | Living Tadpoles Counted | Dead Tadpoles Counted |
|---|---|---|---|
| 1 | 1 | 5 351 | 132 |
| | 2 | 6 315 | 3 |
| 2 | 1 | 1 883 | 7 |
| | 2 | 480 | 2 |
| 3 | 1 | 4 565 | 40 |
| | 2 | 2 442 | 40 |
| | TOTAL | 21 036 | 224 |

The number of eggs present in each egg mass were estimated based on the sum of the hatchling tadpoles and dead tadpoles recorded at the time of the tadpole counting. The number of eggs present in each egg mass ranged between 482 and 6 318 (Table 1). Tadpole mortality was low in each of the 6 exclosures. A small number of eggs from each egg mass appeared to be infertile and were white in color.

### 4.1.2 Rearing site

The tadpoles were distributed equally between the two rearing ponds. A total of 3 590 recently hatched tadpoles were transferred from the east pond (egg mass 2 - draw site 1) into the west pond (Table 2).

Table 2. Distribution of tadpoles released in east and west rearing pond and large predator exclosure in 2001.

| Draw Site | Egg Mass | Tadpole Numbers | | |
|---|---|---|---|---|
| | | East Pond | West Pond | Large Exclosure |
| 1 | 1 | 5 351 | - | - |
| | 2 | 2 725 | 3 590 | - |
| 2 | 1 | - | 1 883 | - |
| | 2 | - | 480 | - |
| 3 | 1 | - | 3 565 | 1 000 |
| | 2 | 1 442 | - | 1 000 |
| | SUBTOTAL | 9 518 | 9 518 | 2 000 |
| | GRAND TOTAL | 21 036 | | |

In total, 20 328 live tadpoles were released into the two ponds (n = 9 518 in east and west pond on 28-29 May; n = 815 in east pond and n = 477 in west pond on 19 June). Of the 20 328 living tadpoles introduced into the ponds, 2 983 metamorphs were captured representing a survival rate of 14.7 %. The east pond exhibited a higher survival rate (18.7 %) compared to that of the west pond (10.6 %).

The west rearing pond initially contained 9 995 tadpoles, but produced considerably less yearling frogs (1 055). The yearling frogs in the west pond had an average SVL of 37.9 mm and weight of 6.2 g (n = 96). It was suspected that an estimated 75% of the tadpoles introduced into the west pond may have experienced mortality resulting from limiting conditions (i.e. anoxic conditions)

produce from a persistent algae bloom that plagued the pond for the entire summer. If this was in fact the case, then the relatively large size of the recent metamorphs may be a result of a lower number then expected tadpoles that inhabited the pond most of the summer.

The smallest average SVL and weights of the metamorph frogs were measured from the east rearing pond, in which 10 333 tadpoles were introduced. A total of 1 928 yearling frogs were collected from the east rearing pond with an average SVL and weight (n = 160) of 33.4 mm and 4.1 g, respectively.

The larger predator exclosure tested in 2001 had limitations. A sample of tadpoles were collected from the large predator exclosures positioned in the rearing ponds and compared to free-ranging tadpoles collected from the same rearing pond. The tadpoles confined to the large predator exclosures were considerably smaller than the free-ranging tadpoles (Photo 7).

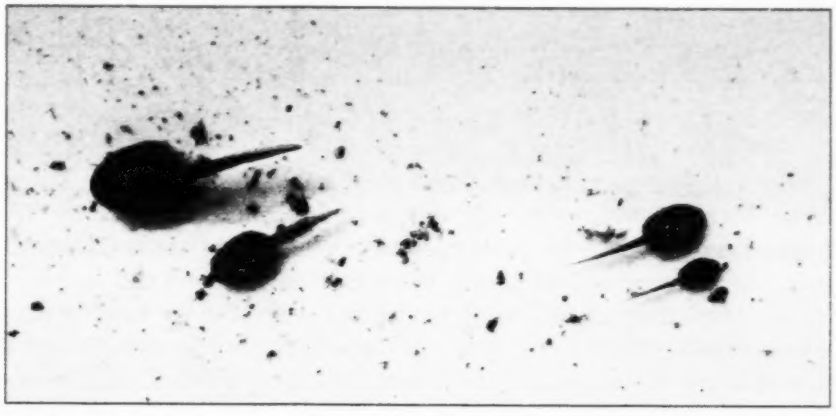


Photo 7. Comparison of representative free ranging tadpoles captured from the east rearing pond (on left side of photo) and tadpoles prior to release from the large predator exclosure (on right side of photo).

Of the 1 000 tadpoles placed into each of the large predator exclosures, 815 and 477 tadpoles were counted in the east and west exclosure, respectively, on 19 June. A mortality rate of 18.5% was observed in the east pond exclosure and a rate of 52.3% was observed in the west pond exclosure. These rates were higher than the mortality rate in each of the rearing ponds.

The average weight and snout-vent-length (SVL) of recent metamorphs in 2001 were smaller than that of the frogs reared in previous years. Metamorphs captured from the east pond approximately six days after mass emergence averaged 4.1 g / 33.4 mm SVL (n=160) and metamorphs captured one to three days after mass emergence averaged 6.2 g / 37.9 mm SVL (n=96) from the west pond. Upon initial emergence from the east and west pond, frogs averaged 4.2 g / 32.9 mm SVL (n=19) and 4.2 g / 32.8 mm SVL (n=29), respectively.

### 4.1.3 Water quality

Water quality at the three draw sites on 1 May was similar to water quality present in the rearing ponds at the Raven Brood Trout Station on 2 May (Appendix C). The general hardness (GH)

and alkalinity (KH) values at the draw sites were higher than those recorded in the rearing ponds. GH and KH values at the three draw sites exceeded the measurable scale of the test and were much higher than 214.8 ppm. GH and KH values recorded in the rearing ponds varied greatly from test date to test date. GH and KH values recorded in the east pond ranged between 179.0 ppm and < 214.8 ppm and 161.1 ppm and < 214.8 ppm, respectively. Whereas, GH and KH values recorded in the west pond ranged from 161.1 ppm to < 214.8 ppm. Nitrate levels were recorded at 0.5 ppm at each draw site and in the rearing ponds throughout the rearing period. In contrast, levels of phosphate, nitrite and ammonia were found to be at 0 ppm or trace at both draw sites and in the rearing ponds. The pH recorded at the draw sites ranged between 7.6 and 8.2. The pH values recorded in the rearing ponds throughout the rearing period fluctuated frequently and ranged between 7.6 and 8.8. Water temperatures measured mid day in the east and west rearing pond averaged 20.4 °C and 20.0 °C, respectively.

### 4.1.4 Tadpole development

Egg mass deposition, hatch and metamorphosis dates were recorded or estimated. It was estimated that the egg masses were deposited between 20 April and 30 April based on the freshness of their appearance and the time it took for them to ultimately hatch after collection (see Dickerson 1906, Wright 1914, 1920, Hine *et al.* 1981, Souder 2000, Kendell 2001 for leopard frog egg development and hatching time). All egg masses were collected on 1 May and began to hatch between 10-14 May. All egg masses had completely hatched by 18 May. Eleven to 12 days after hatching, the tadpoles were release into the rearing ponds (28-29 May). The first metamorphosed frog was observed on 27 July in the east rearing pond and on 7 August in the west rearing pond. Mass emergence of frogs began on 1 August in the east rearing pond and 10 August in the west rearing pond. The majority of the leopard frogs, captive-reared in the two rearing ponds, morphed by 16 August. An unknown and comparably limited number of leopard frogs metamorphosed after 16 August from both rearing ponds.

## 4.2 New release site investigations

Sites with adequate breeding, summering and over-wintering leopard frog habitat attributes, were selected for potential release sites. Long-term conservation potential and dispersal opportunities from release sites were also important. Through ground truthing, it was determined that the majority of the sites investigated in 2001 possessed a number of these preferred characteristics (Appendix G).

Fisher (1999) surveyed two of the 20 potential release sites investigated in 2001. Ultimately, it was decided that both of these previously investigated sites (Buster Creek site and The Gaetz Lakes) lacked the required criteria for a suitable release site (Appendix G). Of the 20 sites investigated, six sites were linked with BSOD records or were located in close proximity to historic leopard frog records. The sites with associated BSOD records include, The Gaetz Lakes (BSOD # 51326), Tail Creek (BSOD # 51304), Crimson Lake (Crimson Lake Provincial Park) (BSOD # 8346) and the Wommacks Lakes (near Crammond) (BSOD # 8034). A number of leopard frog records also occur in the Buffalo Lake area (for example, BSOD # 608, 9458, 9462) and the Rocky Mountain House area (for example BSOD # 8239).

Of the sites surveyed, the North Saskatchewan River site was selected as the premium site to release frogs in 2001 (see section 4.3.2 and Appendix G). Other notable sites that exhibited a number of preferred habitat attributes and characteristics included the Hummer Property (Middle Wooden Lake) (Photo 8) and the Rocky Mountain House National Historic Site (Photo 9).

Photo 8. Hummer Property (Middle Wooden Lake) potential release site investigated in 2001.

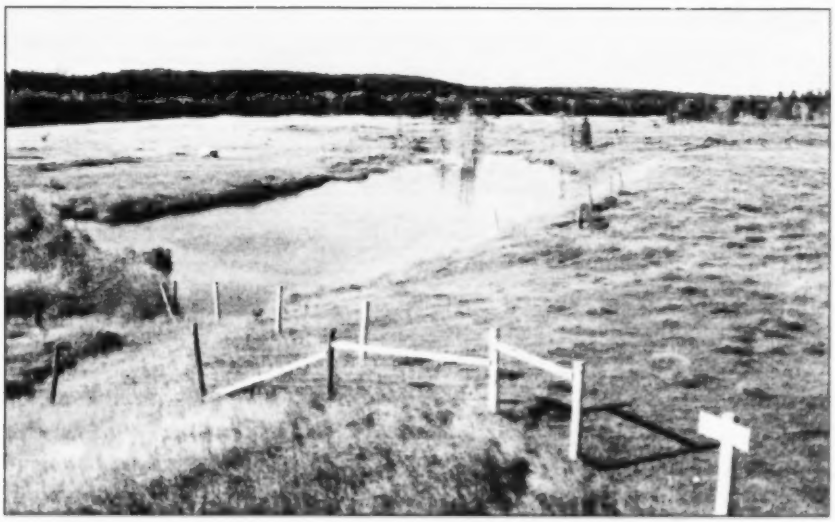


Photo 9. Rocky Mountain House National Historic Site located near Rocky Mountain House and along the North Saskatchewan River.

## 4.3 Release (2001)

The collection of captive-reared frogs began on 1 August from the east rearing pond. The collection of captive-reared frogs from the west pond began on 7 August. Approximately 73% of the recently transformed young frogs from both ponds were marked with elastomer and released between 1 August and 16 August. The remaining frogs (27%) from both ponds were marked and released between 17 August and 31 August.

Leopard frogs reared in 2001 were released at the Raven River release site and the North Saskatchewan River release site. The Raven River release site is composed of two separate release areas called the oxbow site (Site 1) and the cooling pond site (Site 2). The North Saskatchewan River release site consisted of only one release site. In total, 2 833 captive-reared frogs were marked and released into three separate release sites in 2001 (Appendix E and Table 3). See section 4.3.1 and 4.3.2 for further description of the 2001 release sites.

Table 3. Summary of numbers of captive-reared leopard frogs released at each release site in 2001 and detained in the east rearing pond.

| **Release Site** | **Numbers Released** | | |
|---|---|---|---|
| Raven River – Site 1 | 1 300 | - | - |
| Raven River – Site 2 | 783 | - | - |
| North Saskatchewan River (Release Site 1) | - | 750 | - |
| East Rearing Pond | - | - | 150 |
| SUBTOTAL | 2 083 | 750 | 150 |
| GRAND TOTAL | 2 983 | | |

### 4.3.1 Raven River release site

The Raven River release site is located near the Raven Brood Trout Station and consists of two separate release areas. The first area is located along the Raven River approximately 0.75 km north of the station (oxbow release site). The second release area is located south and west of the Raven Brood Trout Station (cooling pond release site). Frogs released at this site were marked with red elastomer on the right hind foot. Both release areas possessed potential leopard frog breeding, summering and over-wintering habitat. See Kendell 2001 for a detailed description of the oxbow and cooling pond release sites.

Dry conditions at the oxbow release site in 2001 resulted in frogs being released several hundred meters upstream along the Raven River to an area with more permanent ponds. Habitat in that area was similar to that found at the original oxbow release site, as was the physical attributes of the Raven River (i.e. flow and stream bank vegetation). The upland habitat away from the river consisted of hay fields.

### 4.3.2 North Saskatchewan River release site

Of the 20 potential release sites investigated, the North Saskatchewan River release site was chosen as the best site to release leopard frogs. The site itself was a permanent beaver pond located 100-300 m south and west of the North Saskatchewan River, downstream from the

confluence of Buster Creek and the river. It was situated along an escarpment and on the flood plain of the North Saskatchewan River (Photo 10).

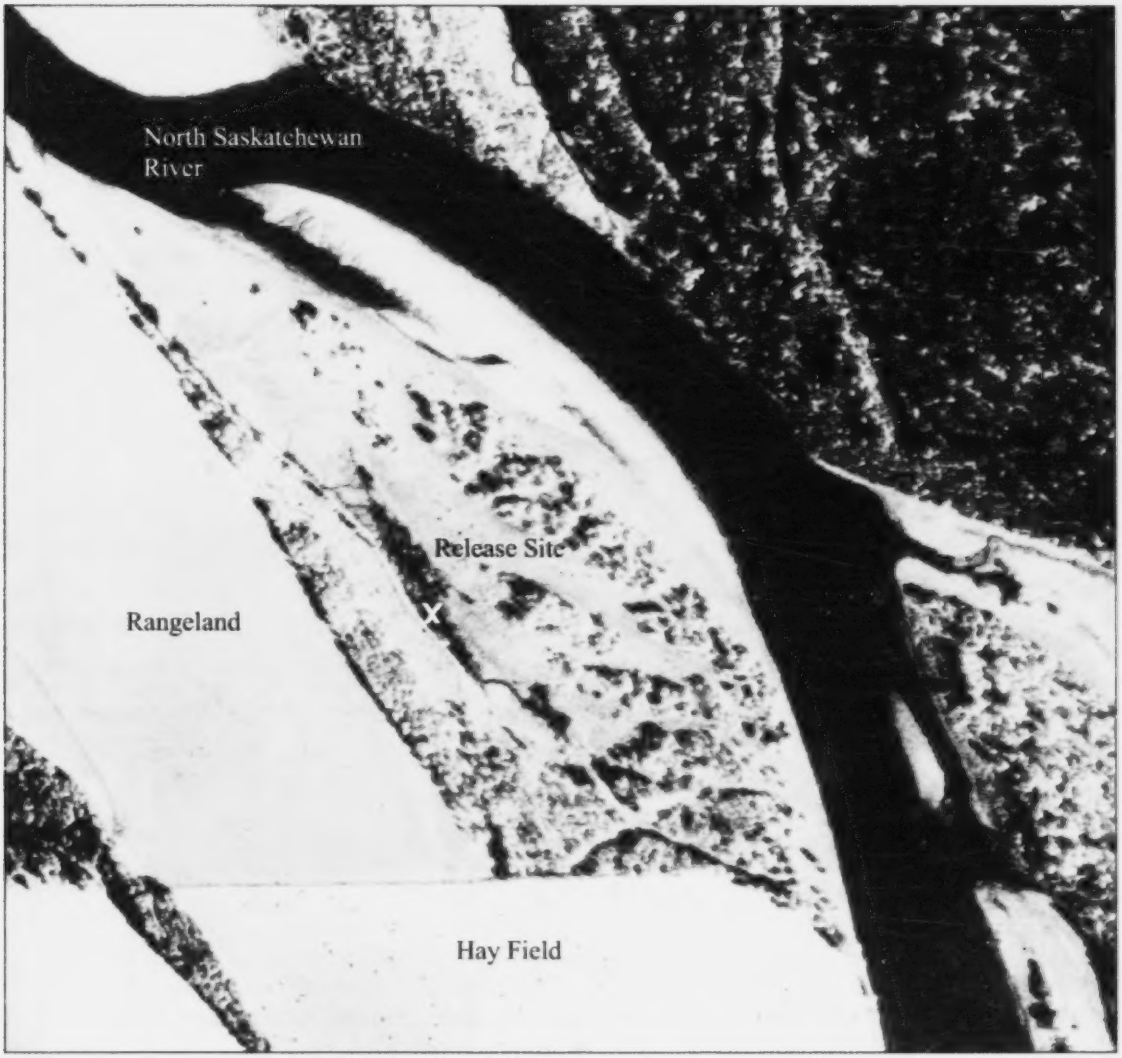



Photo 10. North Saskatchewan River pilot release study area (release site marked with an 'X').

No in-flow or out-flow was noted in the beaver pond in 2001. No surface spring water of seeps were observed at the site and it is unclear if the pond is fed with spring water from beneath the surface or if the river, through the ground, influences the site. The water depth in the pond measured at one point near the beaver lodge was approximately 6 feet. Several beaver runs and shallow bays offer a variety of water depths throughout the wetland complex.

Deep areas in the pond, particularly near the beaver lodge, may provide adequate over-wintering habitat for the released leopard frogs. Other areas of the pond may also be suitable, especially if the pond is influenced by spring water. The presence of the beaver lodge and the observation of

confluence of Buster Creek and the river. It was situated along an escarpment and on the flood plain of the North Saskatchewan River (Photo 10).

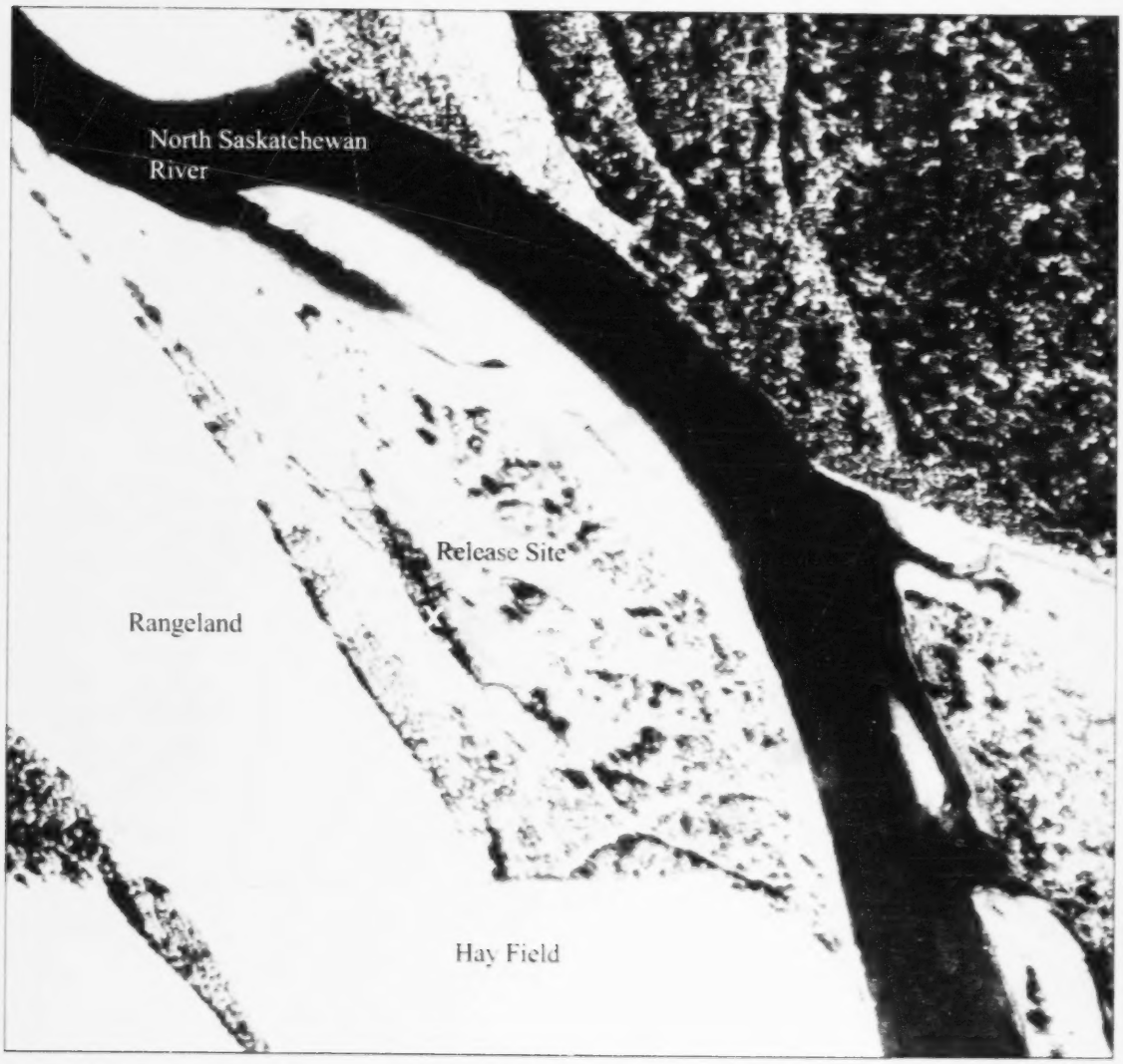



Photo 10. North Saskatchewan River pilot release study area (release site marked with an 'X').

No in-flow or out-flow was noted in the beaver pond in 2001. No surface spring water of seeps were observed at the site and it is unclear if the pond is fed with spring water from beneath the surface or if the river, through the ground, influences the site. The water depth in the pond measured at one point near the beaver lodge was approximately 6 feet. Several beaver runs and shallow bays offer a variety of water depths throughout the wetland complex.

Deep areas in the pond, particularly near the beaver lodge, may provide adequate over-wintering habitat for the released leopard frogs. Other areas of the pond may also be suitable, especially if the pond is influenced by spring water. The presence of the beaver lodge and the observation of

small fish (unknown sp.) provide strong evidence that entire pond does not freeze solid in winter. The close proximity of the North Saskatchewan River to the release site offers a further over-wintering option for the released leopard frogs. However, the section of the North Saskatchewan River in the area of release site is subjected to heavy ice jamming in the winter resulting from the operations of the Big Horn Dam located near Nordegg (personal comm. Konynenbelt, Herman, local landowners). The possible effects of this ice jamming on over-wintering leopard frogs that may attempt to use the river for hibernation is unknown at this time.

The beaver pond has abundant aquatic and emergent vegetation that provides cover for all age classes of leopard frogs, as well as points for the attachment of egg masses. Cattails (*Typha latifolia*) are present along one half of the shoreline at the release site. The remaining shoreline of the pond consists of a stable substrate of grass, sedge and forb. These areas support the basking behaviour of the leopard frog. Areas around the beaver lodge and along the escarpment are void of vegetation and consist of bare soil and debris (i.e. woody materials). The shallow and sheltered bays within the pond offer good breeding habitat for leopard frogs (Photo 11).

Photo 11. Beaver pond release site located along the North Saskatchewan River.

Upland habitat between the beaver pond and the North Saskatchewan River include a open field with shrubs, grasses and forbs which give way to a thin band of trees consisting of popular (*Populus balsamifera*), apen (*P. tremuloides*) and young white spruce (*Picea glauca*). The habitat immediately east and north of the beaver pond is open and void of trees and shrubs. The west side of the beaver pond (escarpment side) is vegetated by an open stand of deciduous trees including aspen and shrubs such as silver willow (*Elaegnus commutata*). This open forest quickly gives way to rangeland consisting of grass and forbs species. Cattle activity in the area surrounding the pond has kept the forest and understory open.

Dozens of wetlands exist along the North Saskatchewan River both upstream and downstream of the selected release site and include backwaters, beaver ponds, side channels and oxbows. Some are attached to the North Saskatchewan River while others are isolated and spring-fed. Ample suitable summering and over-wintering leopard frog habitat is present both upstream and downstream of the release site.

## 4.4 Leopard frog surveys (2001)

On 19 June 2001, three captive-reared leopard frog were documented within the Raven River release study area marking the first confirmed leopard frogs to have successfully survived hibernation in the area. The first frog observation occurred in the east rearing pond at 14:15 on 19 June. The frog was captured, weighed and measured, and the dorsal pattern was sketched (see Appendix F for specific information on each frog observed in 2001). Later that afternoon, on 19 June, two more leopard frogs were observed at the oxbow release site near the Raven River.

On 12 July, seven leopard frogs were observed at the oxbow release site, however it was believed that two of the seven frogs were the same frogs that were observed on 19 June. On 7 August, one leopard frog was observed at the oxbow release site and on 24 August, two leopard frogs were observed and captured at the oxbow release site. It is not clear if the leopard frogs observed on 7 August and 24 August at the oxbow release site were part of the group of frogs observed on 19 June and 7 July. Over the summer, 10 subadult and adult leopard frogs were observed within the study area (at both the cooling pond release site and the oxbow release site). Six of the 10 frogs were marked on their left hind foot and three were not marked. Efforts were made to capture all frogs observed, however four frogs could not be captured (Table 4).

Table 4. Summary of elastomer tag color and rear foot marked of leopard frogs observed and captured at the Raven River release study area in 2001.

| Frog | Hind Foot Marked[1] | Mark Colour[2] | Release Year | Observation Location |
|---|---|---|---|---|
| 1 | NA | No Tag | 2000 | Cooling pond release site |
| 2 | Left | Orange | 2000 | Oxbow release site |
| 3 | NA | Frog not captured | ? | Oxbow release site |
| 4 | Left | Orange | 2000 | Oxbow release site |
| 5 | Left | Orange | 2000 | Oxbow release site |
| 6 | NA | Frog not captured | ? | Oxbow release site |
| 7 | NA | Frog not captured | ? | Oxbow release site |
| 8 | NA | No Tag | 2000 | Oxbow release site |
| 9 | Left | Green | 2000 | Cooling pond release site |
| 10 | NA | No Tag | ? | Cooling pond release site |
| 11? | NA | Frog not captured | ? | Oxbow release site |
| 12? | Left | Yellow | 2000 | Oxbow release site |
| 13? | Left | Yellow | 2000 | Oxbow release site |

? It is not clear whether or not frog 11, 12 and 13 was a different individual frog then that of frog 1-10.

1 Frogs marked on their left hind foot indicates frogs captive-reared and released in 2000.

2 Frogs marked with orange elastomer in 2000 were released at the oxbow release site, frogs marked with green elastomer in 2000 were released at the cooling pond release site and frogs marked with yellow elastomer in 2000 were detained in the west rearing pond to be over-wintered.

On 2 August 2001, a single leopard frog (Frog 1) was heard calling from the east rearing pond, marking the first evidence of breeding behaviour in the study area. A second male frog was believed to be calling in the distance, but this could not be confirmed. Several days later, a second male leopard frog (Frog 10) was observed in the east rearing pond along with the original

male (Frog 1). It was not possible to ascertain that all of the leopard frogs observed in 2001 were 1999 or 2000 release frogs since not all frogs had an elastomer tag on either foot and four were not captured.

Recaptures were limited to four frogs (Frog 1, Frog 2, Frog 9 and Frog 10) and multiple observations (n = 2) of the same frog (based on dorsal pattern, location and frog color) occurred at least once (Frog 3). Recaptured frogs demonstrated considerable changes in both SVL and weights between each capture (n = 2-3), which ranged from 3 to 43 days apart (Appendix F).

## 5.0 DISCUSSION

The observations of at least 10 captive-reared leopard frogs in 2001 at the Raven River reintroduction site provided compelling evidence for the initial success of the project. In addition to the observed leopard frogs, two frogs were heard calling near the Raven Brood Trout Station. The first frog (Frog 1) was heard calling from the east rearing pond and a second frog (Frog 10) was heard calling, in response to the first frog, from the cooling pond (cooling pond release site). In total, as many as 13 leopard frogs were observed in 2001 at the cooling pond release site and oxbow release site, with more observations (n = 7 to 10) occurring at the oxbow release site than at the cooling pond release site (n = 3).

The relatively small number of leopard frogs observed in 2001, is not a true reflection of the actual number of individual frogs occurring within the Raven River release study area. Likely, there were a number of additional leopard frogs present in the Raven River study area, but could not be detected. In addition, a number of released leopard frogs may have dispersed out of the original release areas, into suitable habitat abroad.

Of the 13 frogs observed, nine were captured and of these, six were marked with green (n = 1), orange (n = 3) or yellow (n = 2) elastomer (Appendix F). Because all six frogs were marked on the left hind foot it was clear that these frogs were captive-reared and released in 2000. This indicates the six frogs survived one winter and are second year frogs (i.e. 1 year old frogs). Of the nine frogs captured, three frogs were not marked on either hind foot and therefore it is unknown if these three frogs were captive-reared and released in 1999 or 2000. The remaining four frogs, that were not captured, were simply observed in the field.

Estimated SVL of a Quebec population of leopard frogs at their first, second and third winter, based on a skeletochronology (Leclair and Castanet 1987), ranged between 31-56 mm at the first winter, followed by 65.7 mm at the second winter and 78.4 mm by the third winter. As suggested by Leclair and Castanet (1987) findings, most frogs captured in 2001 were considered to be approaching their second winter. Exceptions include Frog 9 (which was under the suggested SVL) and Frog 1 and Frog 10 which could be second winter frogs, based on body length (i.e. 2 years old) (see Appendix F).

A variety of studies and field observations have shown that leopard frogs are capable of migrating and dispersing over great distances, especially under favourable conditions that encourage movements. Seburn et al. (1997) found that young frogs were capable of dispersing

up to 1 km within three weeks of metamorphosis. It is possible that many of the frogs released in 1999, 2000 and 2001 dispersed outside of the study area by their first winter. Abundant aquatic corridors (i.e. Beaver Creek and the Raven River) present in the Raven River release study area would further facilitate the dispersal of released frogs over-time and a great distance from the release sites. For example, young frogs dispersed up to 8 km downstream from natal ponds by the following spring in one study (Seburn et al.1997).

Adult leopard frogs are equally capable of long distant movements over time. For example, Dole (1971) recaptured leopard frogs over 5 km from their natal pond two years after metamorphosis. Leopard frogs are capable of migrations as much as 1.6 km, year after year, as they travel between over-wintering and breeding habitat (Hine et al. 1981, Souder 2000). Two individual frogs (Frog 12 and Frog 13 - marked with yellow elastomer) demonstrated the greatest confirmed movement of released frogs. Both frogs were released in the west rearing pond in the fall of 2000, to be over-wintered, and were captured in 2001 along the Raven River. A distance of approximately 1 km separated their release site and where they were observed in 2001. Surveys for released leopard frogs, at the Raven River release site and the pilot North Saskatchewan River release site, should incorporate suitable habitats several kilometres downstream from the both study areas. These surveys may result in discoveries of additional released leopard frogs and possibly established populations.

It is presumed that young-of-the-year frogs disperse to find new adjacent habitats suitable for breeding and summer, as well to discover over-wintering habitat for successful hibernation. A proportion of the released frogs will adopt their release sites as their natal pond and will return year after year to the site to breed. All but two of the leopard frogs encountered in 2001 were observed in or near breeding habitat that was associated with their respective release site (Appendix F).

The overall success of the project at the Raven River release site can only be considered once a self-sustaining population is established. Initial success at the North Saskatchewan River release site will occur in 2002 if frogs released in 2001 are detected and confirmed to have survived hibernation. Similarly, the overall success at that site will depend on the deposition of egg masses by previously released frogs and successful metamorphosis of those tadpoles. The success of the project, to date, is largely attributed to the detailed knowledge of the leopard frog's reproductive biology and ecological requirements through metamorphosis.

Knowledge of the optimal number of animals required to successfully establish a population in a given area is poorly understood. Mortality in metamorphs can result from depredation, disease, malnutrition and unfavourable environmental conditions. Mortality during hibernation is especially significant and can range as high as 90% (Biota Consultants 1992). Merrell and Rodell (1968) estimated winter mortality of adult leopard frogs to be approximately 60%. Yearling mortality can range even higher. A mark-recapture experiment with yearlings in the Cypress Hills showed that a cohort of frogs from a pond was reduced from approximately 5 909 frogs in the summer of 1993 to 385 frogs in the spring of 1994. When the 1993 pre-hibernation estimate was compared to the post-hibernation estimate a mortality rate of approximately 93% was recorded (Yaremoko 1994).

The survivorship of young frogs through their first and future winters is critical to the sustainability of the population. Therefore, the number of frogs released must sufficiently compensate for mortality. If the mortality rate exceeds the recruitment rate, than the population will go extinct. As a result, the number of frogs captive-reared and release must exceed the mortality rate at the release site.

A number of environmental and physical factors during tadpole development affect frog size upon transformation. Such factors include availability and quality of food, predator numbers, water quality (i.e. water temperature), and tadpole density. The crowding of tadpoles can result in stunted growth (Adolph 1931), decreased growth rates (Lynn and Edelman 1936) and a decrease in mean body mass of metamorphs (Wilbur 1976). Understanding the carrying capacity of the rearing ponds will help to reduce tadpole stress during development and increase the size and body mass of metamorphs. Larger frogs at metamorphosis would be better physiologically adapted for escaping predators and hunting for prey in a terrestrial environment after emergence, thus increasing their survival rate (Pough and Kamel 1984, Goater et al. 1993). Furthermore, larger metamorphs may result in earlier first reproduction and larger size at first breeding.

The size of recent metamorphs under natural conditions can be used as a rough guideline to determine the preferred or target size of captive-reared frogs upon metamorphosis. The average SVL of yearling frogs, according to a handful of studies of wild populations of leopard frogs, indicate that the SVL may range between 31.0 mm and 40.7 mm (Eddy 1976, Yaremko 1994, Seburn 2000). Under good development conditions (i.e. low tadpole densities, etc.), the SVL of recent metamorphs can range between 48-50 mm SVL (Merrell 1969 in Merrell 1977). Tadpoles that develop under poor or stressful conditions resulting from predator pressures, high tadpole density or drying of the pond may have a smaller average metamorph size of 25-30 mm SVL (Merrell 1977). Recent metamorphed frogs measured in 2000 and 2001 ranged between 33.4 mm and 41 mm. These measurements suggest that frogs produced in both 2000 and 2001 were comparable to the average SVL of metamorphs procured in nature, as suggested by the above authors.

There is limited information available on weights of yearling frogs. Yaremko (1994) found that 150 yearling frogs weighed from a pond in the Cypress Hills had an average weight of 7 g. It is recommended that a body mass similar to what was observed by Yaremko (1994) be adopted as the preferred weight of frogs raised at the Raven Brood Trout Station.

Nace et al. (1996) recommends that *Rana pipiens* tadpoles near metamorphosis be kept in no more than four to six tadpoles per liter of water. Unfortunately, the true volume of the rearing ponds cannot be accurately measured because of the displacement of water by vegetation and debris in the ponds. It is therefore recommended that the evidence collected in the field be used to predict the ideal number of frogs to be captive-reared in the rearing ponds.

## 6.0 MANAGEMENT IMPLICATIONS AND FUTURE DIRECTIONS

1. The examination of new egg mass draw sites should continue to ensure alternate sites are available to help minimize possible pressures on the current sites and diversify genetic diversity at release sites. Leopard frog populations west of Stavely, Alberta should be studied to better understand population demographics in that area. Potential leopard frog populations located near Brooks and south of the Cypress Hills should also be considered for potential draw locations of egg masses. Local biologists responsible for the management of areas of interest should be contacted prior to surveys and other work conducted.

2. In order to produce the optimal number of young-of-the-year leopard frogs from the two rearing ponds at the Raven Brood Trout Station, without compromizing metamorph health, it is recommended that 6 000 tadpoles be reared stocked into each rearing pond. To ensure at least 6 000 tadpoles are available for release into each rearing pond, at least 3 egg masses should be collected (each averaging at least 4 000 eggs). A fourth egg mass may be required if only small egg masses can be collected. If the survival rate of the tadpoles through development to metamorphosis is approximately 20%, 2 400 yearling frogs could be available for release.

3. Each rearing pond should be held at the maximum water depth possible with the existing standpipes fitted on the water-control gates of either pond. This will help to minimize tadpole competition for resources and crowding.

4. Recently transformed frogs emerging from the rearing ponds should be collected, processed and released shortly after metamorphosis. At least 5 days should lapses between the onset of mass emergence of frogs and the commencement of collection to ensure the most effective use of volunteer time and effort.

5. Selected release sites that demonstrated desired criteria favourable for a successful leopard frog reintroduction should be visited at least once during the winter, after freeze up, to assess over-wintering habitat suitability. Ice thickness, dissolved oxygen and water temperatures should be tested at each selected site. Sites of particular importance include the 2001 pilot release site (North Saskatchewan River beaver pond), the Rocky Mountain House National Historic Site and the Hummer Property.

6. Surveys for previously released frogs should be continued at the Raven River release site and at the new North Saskatchewan River release site. Timing of the survey and environmental conditions during each survey will be instrumental in the success of each survey. Surveys should be conducted in early spring, mid summer and again late summer. Additional late fall surveys could provide valuable information on waterbodies used for hibernation. Sampling guidelines outlined in the Survey Protocol for the Northern Leopard Frogs (2001) should be used during the survey for leopard frogs at release sites.

7. Investigations into new potential leopard frog release site should be an on-going component of the Northern Leopard Frog Reintroduction Project. Having a number of release site options would ensure that only the best sites are considered.

8. Long-term monitoring at both the Raven River release site and the North Saskatchewan River release site is critical to enable remedial action such as the relocating egg masses that are deposited in unfavourable habitat, tracking the dispersal of released frogs and general assessment of established populations.

## 7.0 LITERATURE CITED


Adolph, E. F. 1931. The size of the body and the size of the environment in the growth or tadpoles. *Biological Bulletin* 61:350-375.

Alberta Environment. 1996. The Wildlife Act. Alberta Environmental Protection, Natural Resources Service, Edmonton, Alberta 212 pp.

Aquarium Pharmaceuticals Canada. 2000. Freshwater master liquid test kit (instruction manual). Aquarium Pharmaceuticals, Inc. Anjou, QC. 23 pp.

Bardach, J. E., Ryther, J. H., and McLarney, W. O. 1972. Aquaculture: the farming and husbandry of freshwater and marine organisms. Wiley-Interscience, New York, NY. 868 pp.

Biodiversity Species Observation Database (BSOD). 2000. Natural Resources Service / Alberta Conservation Association, Edmonton, Alberta.

Biota Consultants 1992. Eagles Nest Candidate Natural Area Special Features and Range Inventory 1992. Prepared for Alberta Forestry Lands and Wildlife Land Information Services Division. Pp. 41-43.

COSEWIC. 2000. Canadian Species at Risk. Committee on the Status of Endangered Wildlife in Canada. 23 pp.

Cottonwood Consultants Ltd. 1986. An overview of reptiles and amphibians in Alberta's grassland and parkland natural regions. Prepared for World Wildlife Fund Canada. (Wild West Program), Toronto, ON. 63+ pp.

Dickerson, M. C. 1906. The frog book: North American toads and frogs with a study of the habits and life histories of those of the northeastern states. Doubleday, Page and Company, New York, NY. 253 pp.

Dodd, K. C. Jr., and R. A. Seigel. 1991. Relocation, repatriation, and translocation of amphibians and reptiles: are they conservation strategies that work? *Herpetologica* 47(3): 336-350.

Dole, J. W. 1971. Dispersal of recently metamorphosed leopard frogs, *Rana pipiens*. *Copeia* 1971:221-228.

Eddy, S. B. 1976. Population ecology of the leopard frog *Rana pipiens pipiens* Schreber at Delta Marsh, Manitoba. MSc thesis, Department of Zoology, University of Manitoba, Winnipeg.

Fisher, C. 1999. Feasibility of northern leopard frog translocation in Alberta: a review of physiological, ecological, methodological requirements for successful repatriations and results from field investigations. Alberta Environment, Fisheries and Wildlife Management Division, Edmonton, AB. 30 pp.

Goater, C. P., R. D. Semlitsch, and M. V. Bernasconi. 1993. Effects of body size and parasite infection on the locomotory performance of juvenile toads, *Bufo bufo*. *Oikos* 66:129-136.

Gosner, K. L. 1960. A simplified table for staging anuran embryos and larvae with notes on identification. *Herpetologica* 16:183-190.

Hine, R. L., Les, B. L. and Hellmich, B. F. 1981. Leopard frog populations and mortality in Wisconsin, 1974-76. Technical Bulletin No. 122, Department of Natural Resources, Madison, WI. 39 pp.

Kendell, K. 2001. Northern leopard frog reintroduction: Raven River – year 2 (2001). Alberta Sustainable Resource Development, Fish and Wildlife Service, Alberta Species at Risk Report No. 13, Edmonton, AB. 43 pp.

Lynn, W. G., and A. Edelman. 1936. Crowding and metamorphosis in the tadpole. *Ecology* 17:104-109.

McDiarmid R. W. and R. Altig. 1999. Tadpoles: the biology of anuran larvae. University of Chicago Press, London. 444 pp.

Merrell, D. J. 1969. Natural selection in a leopard frog population. *Journal of the Minnesota Academy of Science* 35:86-89.

Merrell, D. J. 1977. Life history of the leopard frog *Rana pipiens*, in Minnesota University of Minnesota Bell Museum of Natural History, Occupational Paper No. 15. 23 pp.

Merrell, D. J., and C. F. Rodell. 1968. Seasonal selection in the leopard frog (*Rana pipiens*). *Evolution* 22:284-288.

Moore, J. A. 1944. Geographic variation in *Rana pipiens*. Schreber of eastern North America. Bulletin of the American Museum of Natural History 82:345-370.

Nace, G. W., D. D. Culley, M. B. Emmons, E. L. Gibbs, V. H. Hutchison, R. G. McKinnell. 1996. Amphibians: guidelines for the breeding, care, and management of laboratory animals. A report of the Subcommittee on Amphibian Standards, Committee on Standards, Institute of Laboratory Animal Resources, and National Research Council. National Academy of Sciences, Washington, D. C. Http://www.nap.edu/readingroom/books/amphibian/index.html [accessed on 06 Dec. 2000]

Northwest Marine Technology, Inc. 2001. Http://www.nmt-inc.com.

Pough, F. H., and S. Kamel. 1984. Post-metamorphic change in activity metabolism of anurans in relation to life history. *Oecologia* 65:138-144.

Seburn, C. N. L., D. C. Seburn, and C. A. Paszkowski. 1997. Northern leopard frog (*Rana pipiens*) dispersal in relation to habitat. In Amphibians in Decline: Canadian Studies of a Global Problem, D. M. Green (Ed.). *Herpetological Conservation*. Society of the Study of Amphibians and Reptiles, St. Louis. 1:64-72.

Souder, W. 2000. A plague of frogs: the horrifying true story. Library of Congress Cataloguing-in-Publication Data, New York, NY. 299 pp.

Stebbins R. C. and N. W. Cohen. 1995. A natural history of amphibians. Princeton University Press, Princeton, NJ. 316 pp.

Wagner, G. 1997. Status of the northern leopard frog (*Rana pipiens*) in Alberta. Alberta Environmental Protection, Wildlife Management Division, Wildlife Status Report No. 9, Edmonton, AB. 46 pp.

Wendlandt, M., and Takats, L. 1999. Northern leopard frog reintroduction: Raven River - pilot year (1999). Alberta Environment, Fisheries and Wildlife Management Division, Edmonton, AB. 22 pp.

Wershler, C. R. 1991. Status of the northern leopard frog in Alberta - 1990. Unpublished report by Sweetgrass Consultants Ltd. for World Wildlife Fund Canada (Prairie for Tomorrow) and Alberta Forestry, Lands and Wildlife, Edmonton, AB. 81 pp.

Wilbur, H. M. 1976. Density-dependent aspects of metamorphosis in *Ambystoma* and *Rana sylvatica*. *Ecology* 57:1289-1296.

Wright, A. H. 1914. Life-histories of the anura of Ithaca, New York, Carnegie Institute Publications, No. 187:1-98.

Wright, A. H. 1920. Frogs: their natural history and utilization. Bureau of Fisheries Document No. 888. Washington Government Printing Office, Washington, D.C. 44 pp.

Yaremko, L. 1994. Northern leopard frog project: field report 1994. Unpublished report to the Department of Environmental Protection, Fish and Wildlife Service, Edmonton, AB. 85 pp.

Appendix A. Site names and co-ordinates of the potential release sites investigated in the Red Deer River and North Saskatchewan River drainage basin.

| Red Deer River Drainage | | | | | |
|---|---|---|---|---|---|
| Site Name | | General ATS | Specific UTM (s) – NAD 27 | | |
| | | | Northing | Easting | Zone |
| 1 | Gaetz Lakes | NE 27-38-27-W4M | 5797296 | 311423 | 12 |
| 2 | The Narrows | 15, 21, 22-40-22-W4M | 5813151 | 359836 | 12 |
| 3 | Hummer Property – Middle Wooden Lake* | NE 36-35-24-W4M | 5768814 | 342645 | 12 |
| 4 | Bigelow Reservoir** | NE 9-34-25-W4M | 5753779 | 329646 | 12 |
| 5 | Great West* | S1/2 32-35-24-W4M | 5796447 | 365790 | 12 |
| 6 | B & E Project* | NW 16-35-25-W4M | 5764723 | 326961 | 12 |
| 7 | Mud Lake – Cassidy Project* | NE 16-37-20-W4M | 5782984 | 377577 | 12 |
| 8 | Ghostpine Creek – WIK Property* | SE 32-35-20-W4M | 5768470 | 336067 | 12 |
| 9 | Big Valley Creek* | 10, 15-35-20-W4M | 5768469 | 382341 | 12 |
| 10 | Tail Creek | 34-38-22-W4M | 5796974 | 358855 | 12 |
| | | | 5796727 | 358903 | 12 |
| 11 | Open Creek Reservoir | 25-42-6-W5M | 5835950 | 654000 | 11 |
| 12 | Beaver Lake** | 15, 16-25-6-W5M | 5764070 | 651668 | 11 |
| 13 | Wommacks Lakes | 29-35-5-W5M | 5761742 | 657087 | 11 |
| | | | 5762489 | 657465 | 11 |
| 14 | North Raven River | 35-5-W5M | 5784242 | 657131 | 11 |
| | | | 5781868 | 661186 | 11 |
| | | | 5782711 | 660008 | 11 |

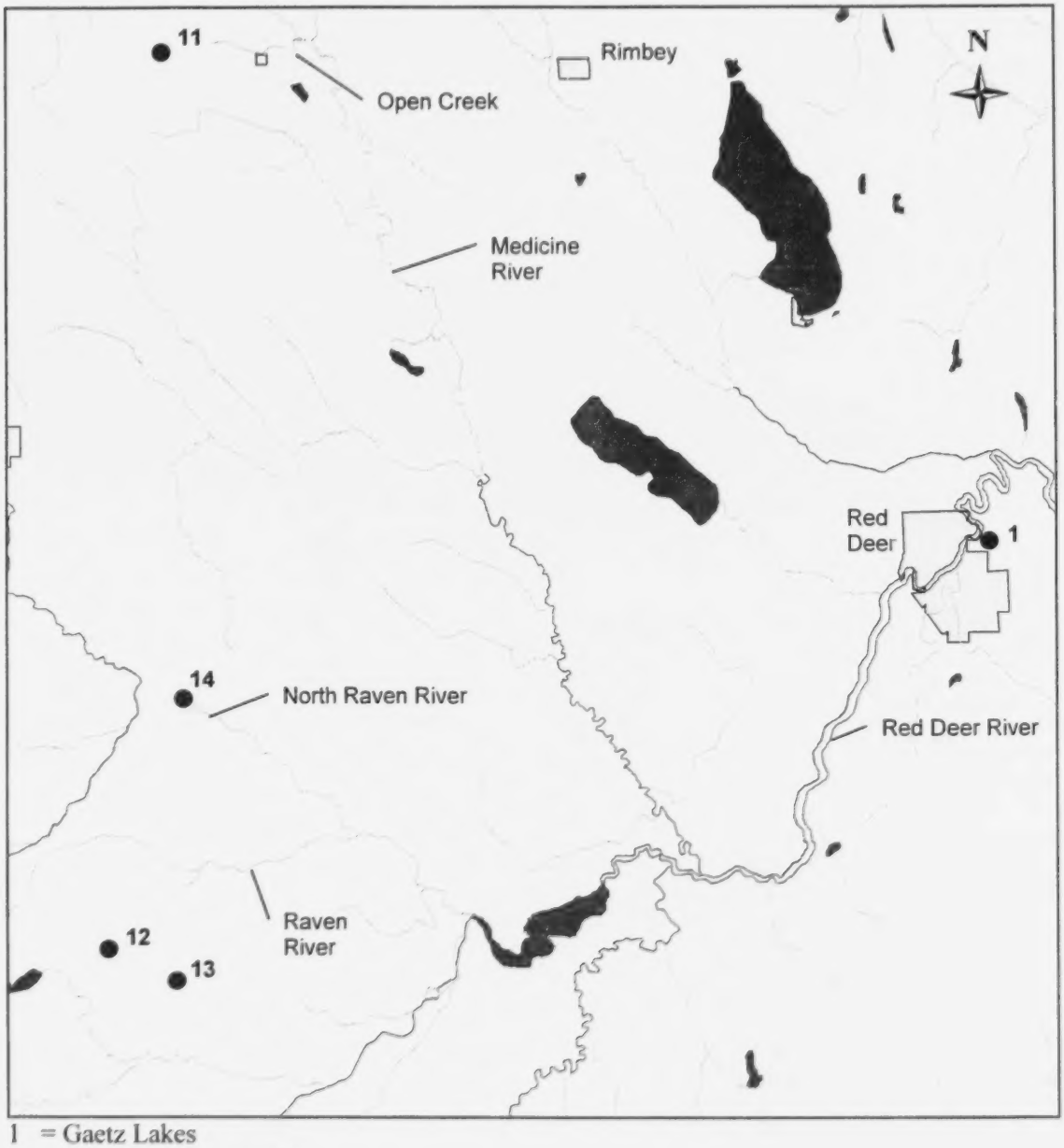
* Ducks Unlimited (Canada) Project

** Buck for Wildlife Project

Appendix A. *continued*

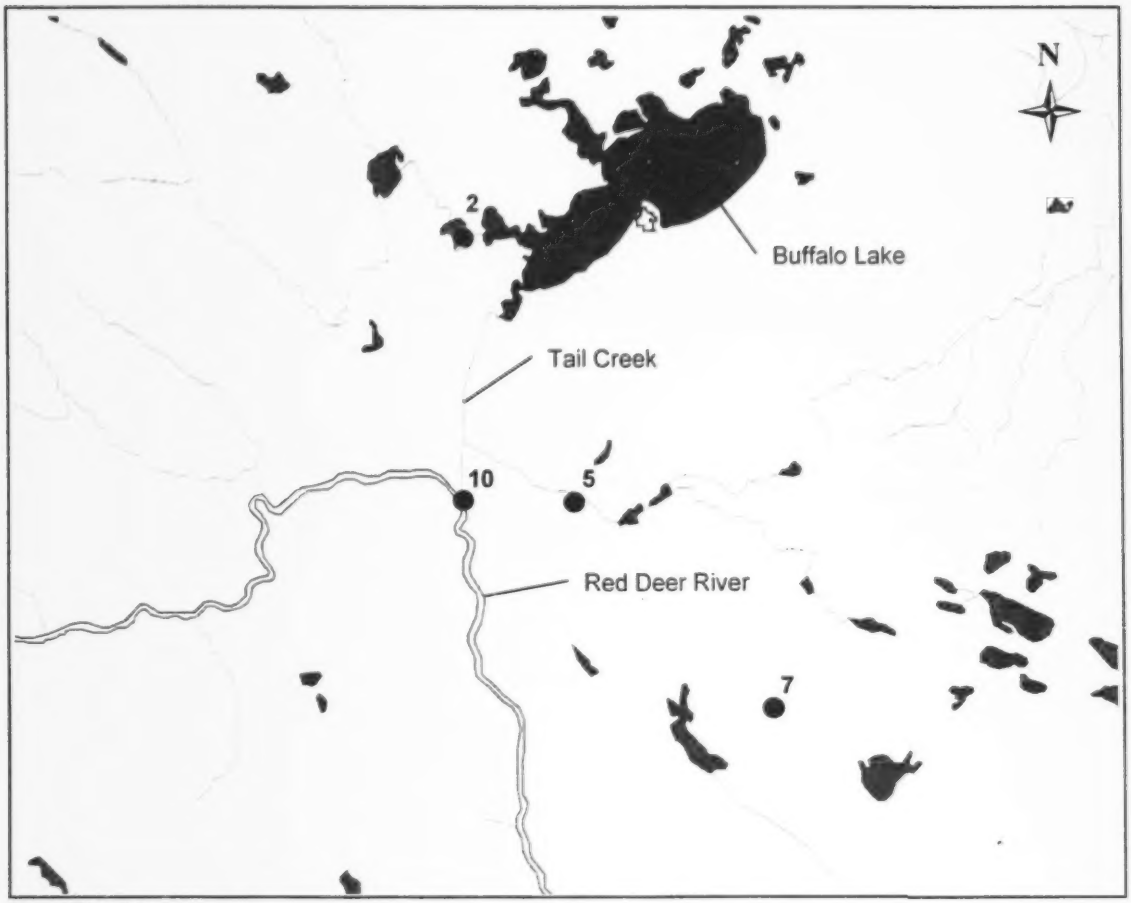
| North Saskatchewan River Drainage | | | | | |
|---|---|---|---|---|---|
| Site Name | | General ATS | Specific UTM (s) – NAD 27 | | |
| | | | Northing | Easting | Zone |
| 15 | Battle River (Big Knife Provincial Park) | 34, 35-40-16-W4M & 4, 3-41-16-W4M | 5816696 | 416775 | 12 |
| | | | 5817220 | 416244 | 12 |
| 16 | Battle Lake | SE 14-46-2-W5M | 5872000 | 690000 | 11 |
| 17 | Rocky Mountain House National Historic Site | W1/2 39-7-W5M | 5802500 | 637900 | 11 |
| 18 | Buster Creek | NE 32-40-8-W5M | 5816792 | 628606 | 11 |
| 19 | Crimson Lake (Crimson Lake Provincial Park) | SE 23-40-8-W5M | 5812722 | 633713 | 11 |
| 20 | North Saskatchewan River (Beaver Pond) | NW 19-41-7-W5M | 5823566 | 635465 | 11 |
| | | | 5823671 | 634861 | 11 |
| | | | 5825260 | 633900 | 11 |

Appendix B. Detailed maps of the 20 potential leopard frog release sites investigated in 2001.



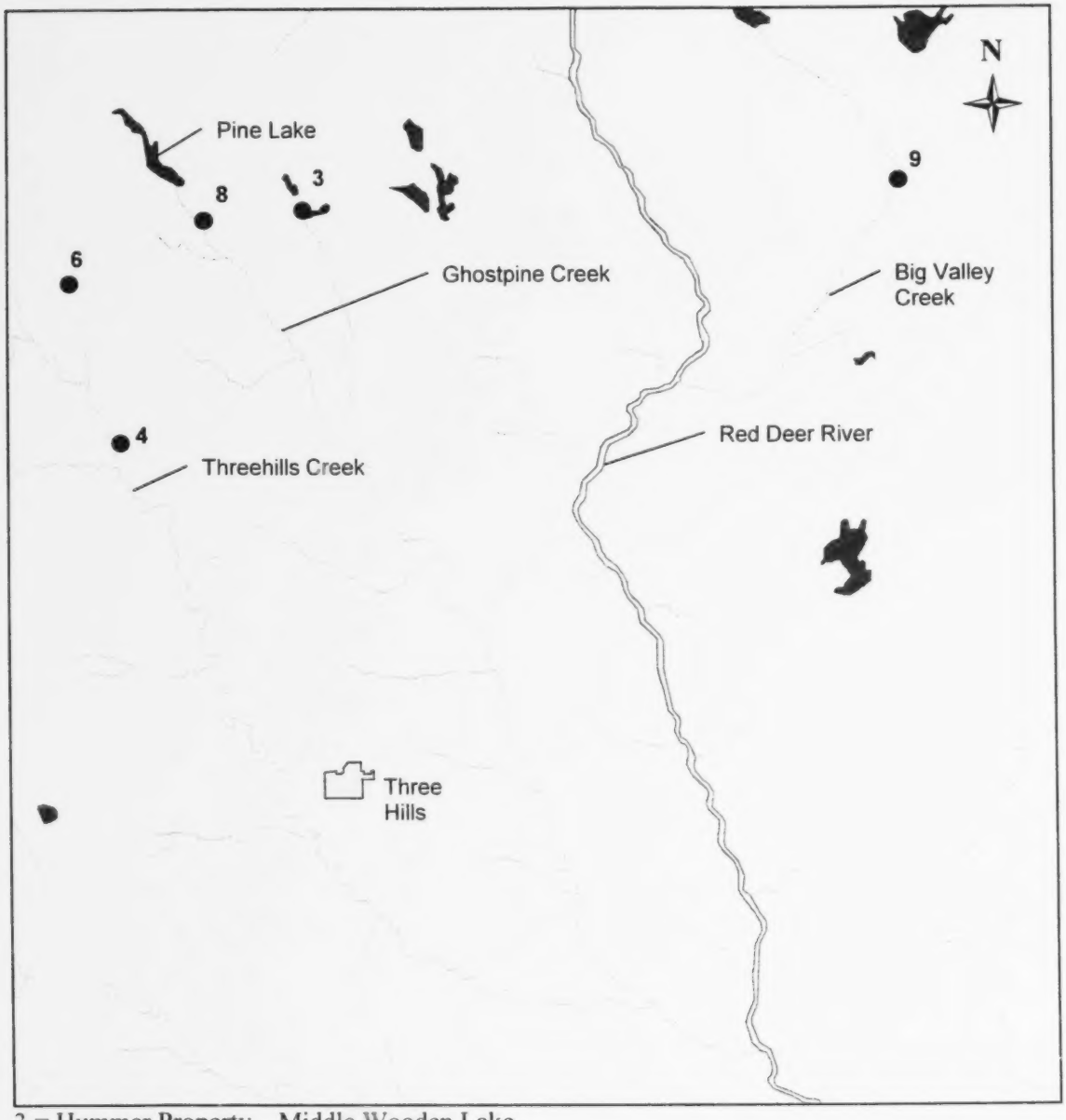

1 = Gaetz Lakes
11 = Open Creek Reservoir
12 = Beaver Lake
13 = Wommacks Lakes
14 = North Raven River

Appendix B. *continued*



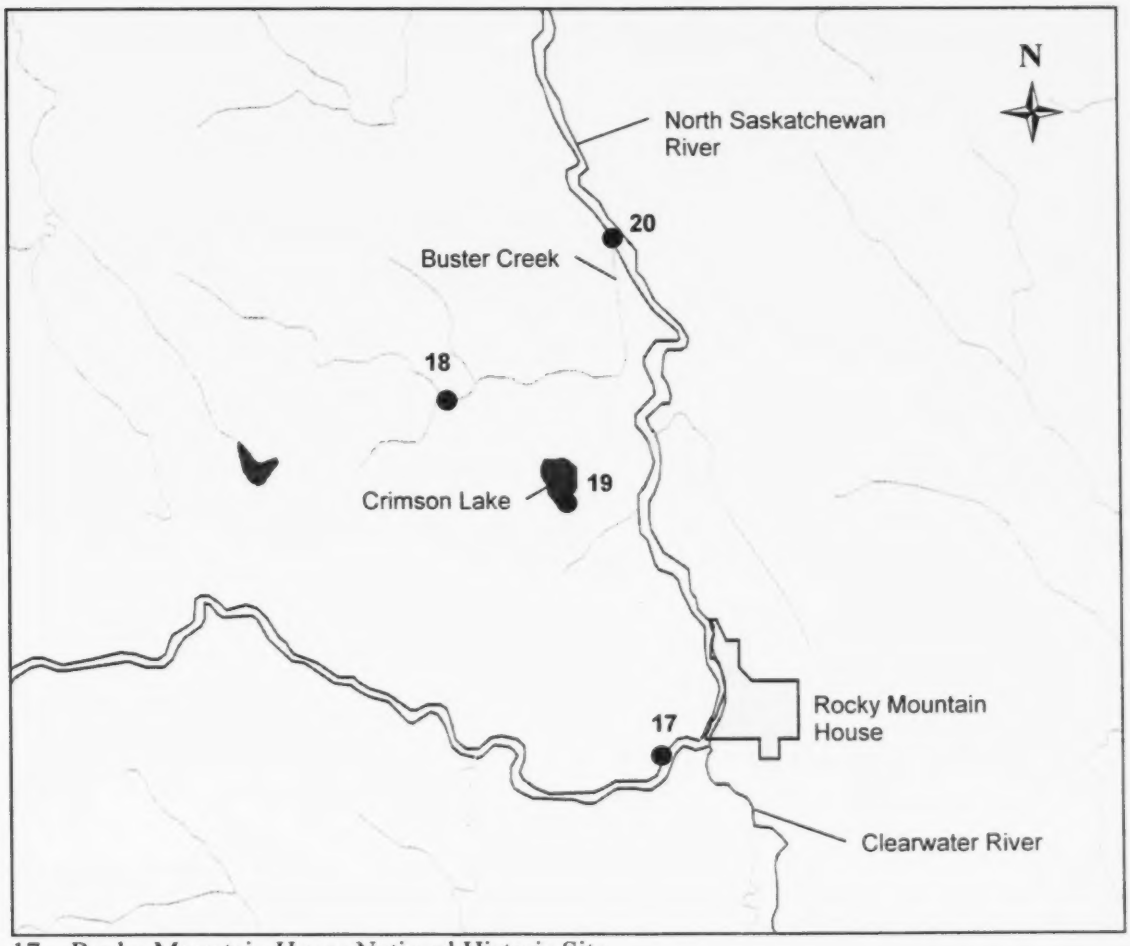

2 = The Narrows
5 = Great West Project
7 = Mud Lake – Cassidy Project
10 = Tail Creek

Appendix B. *continued*



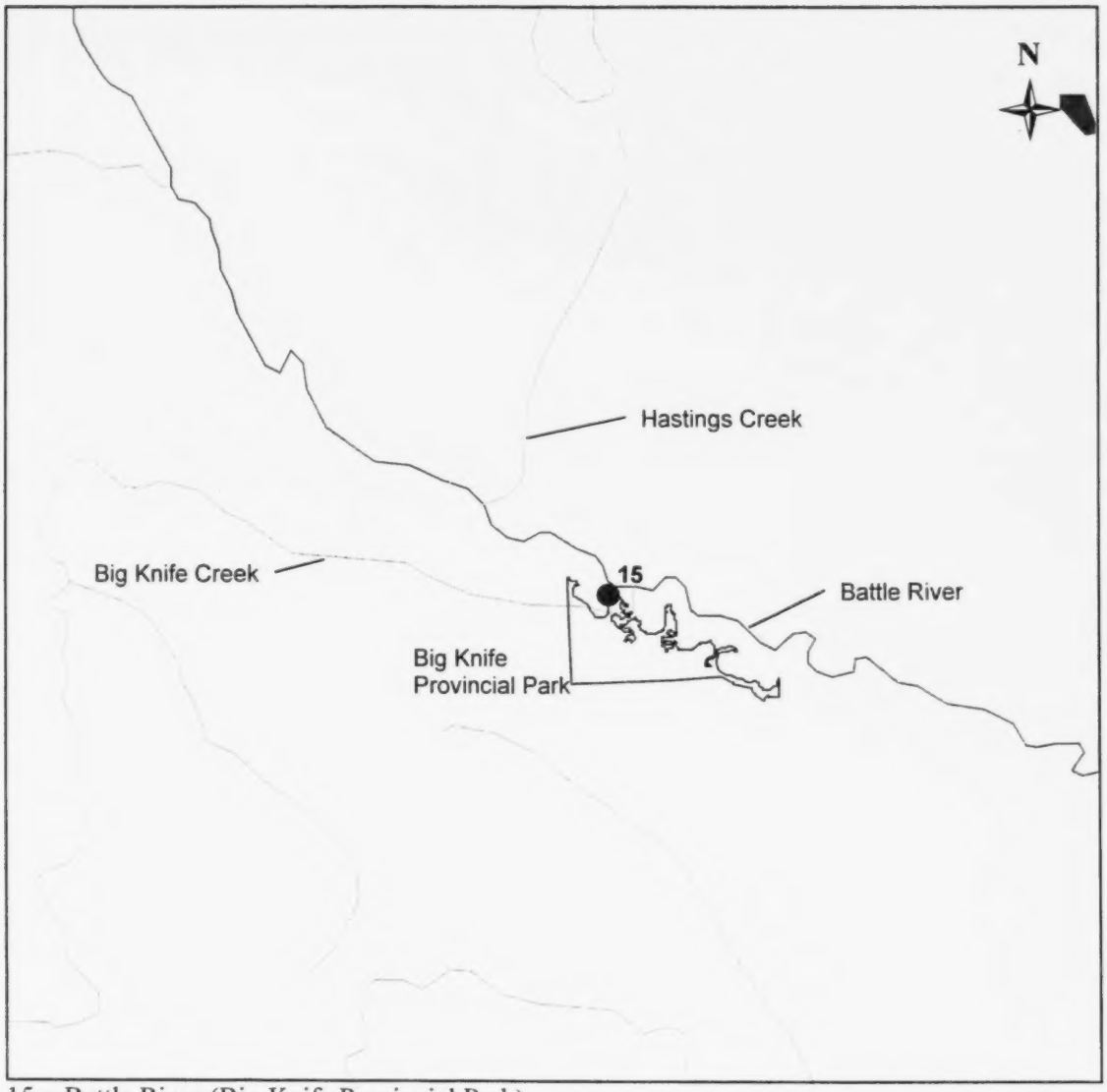

3 = Hummer Property – Middle Wooden Lake
4 = Bigelow Reservoir
6 = B & E Project
8 = Ghostpine Creek – WIK Property
9 = Big Valley Creek

Appendix B. *continued*



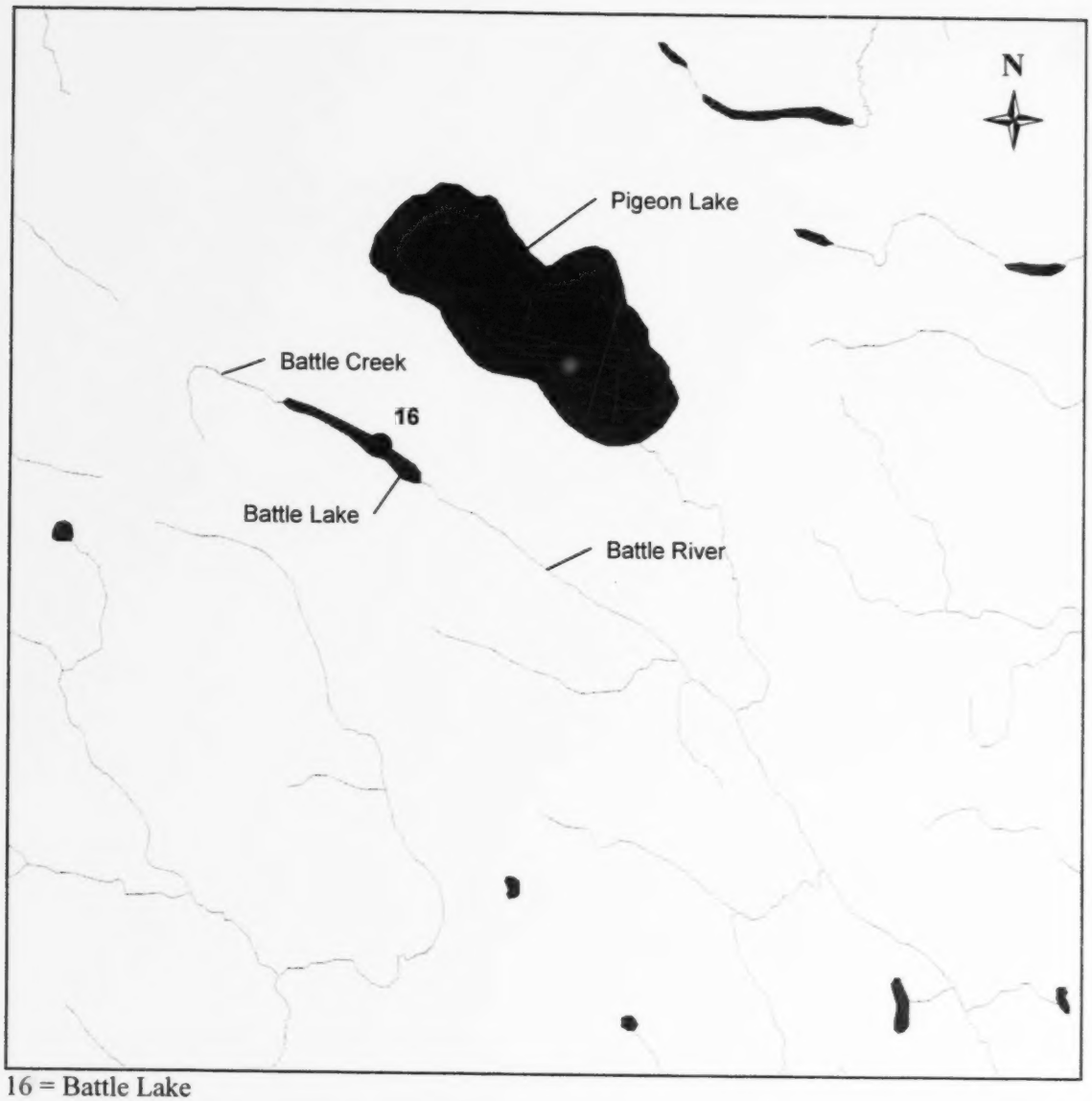

17 = Rocky Mountain House National Historic Site
18 = Buster Creek
19 = Crimson Lake (Crimson Lake Provincial Park)
20 = North Saskatchewan River (Beaver Pond) – 2001 Release Site

Appendix B. *continued*




15 = Battle River (Big Knife Provincial Park)

Appendix B. *continued*




16 = Battle Lake

Appendix C. Water quality, air temperature, time and date of egg mass collection at the three leopard frog egg mass draw sites.

| Location | Date (2001) | Time - 24 hour | Parameter | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | air temp (°C) | water temp (°C) | phosphate (ppm) | nitrite (ppm) | nitrate (ppm) | ammonia (ppm) | pH (ppm) | general hardness - GH (ppm) | alkalinity - KH (ppm) |
| Draw site 1 | 1 May | 10:15 | 15 | 9.0 | 0-0.25 | 0 | 0.5 | 0-0.5 | 7.6-7.8 | <214.8 | <214.8 |
| Draw site 2 | 1 May | 12:00 | 16 | 10.5 | 0 | 0 | 0.5 | 0-0.5 | 7.6-8.2 | <214.8 | <214.8 |
| Draw site 3 | 1 May | 13:30 | 16 | 11.0 | 0 | 0 | 0.5 | 0-0.5 | 7.6-7.8 | <214.8 | <214.8 |

Water parameter test and increments (ppm): phosphate – 0, 0.25, 0.50, 1.00, 2.50, 5.00
nitrite – 0, 0.25, 0.50, 1.00, 2.50, 5.00
nitrate – 5, 10, 20, 50, 110;
ammonia – 0, 0.5-1.0, 2.0-3.0, 4.0-5.0, 6.0-7.0
pH – 6.0, 6.4, 6.6, 7.0, 7.2, 7.6 (high range) 7.4, 7.8, 8.0, 8.2, 8.4, 8.8

Appendix D. Water quality recorded in the two rearing ponds at the Raven Brood Trout Station during the captive rearing period.

**East Rearing Pond**

| Date (2001) | Time - 24 hour | Parameter | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | Air temperature (°C) | water temperature (°C) | phosphate (ppm) | nitrite (ppm) | nitrate (ppm) | ammonia (ppm) | pH (ppm) | general hardness - GH (ppm) | alkalinity - KH (ppm) |
| 2 May | 10:00 | - | 10.0 | 0 | 0 | 0.5 | 0 | 7.9-8.0 | <214.8 | <214.8 |
| 7 May | 08:30 | 12.0 | 9.0 | 0 | 0 | 0.5 | 0 | 7.6-8.0 | 214.8 | 196.9 |
| 9 May | 08:45 | 5.0 | 10.0 | 0 | 0 | 0.5 | 0 | 7.6-8.0 | 196.9 | 214.8 |
| 14 May | 08:30 | 13.0 | 14.0 | 0 | 0 | 0.5 | 0 | 7.6-8.2 | 179.0 | 179.0 |
| 16 May | 08:00 | 9.0 | 13.0 | 0 | 0 | 0.5 | 0 | 7.6-8.0 | 196.9 | 179.0 |
| 23 May | 08:45 | 17.0 | 17.0 | 0 | 0 | 0.5 | 0 | 7.6-8.0 | 214.8 | 179.0 |
| | 15:45 | - | 23.0 | - | - | - | - | - | - | - |
| 24 May | 08:00 | - | 17.0 | - | - | - | - | - | - | - |
| | 16:00 | - | 22.0 | - | - | - | - | - | - | - |
| 25 May | 08:30 | - | 15.0 | - | - | - | - | - | - | - |
| | 15:00 | - | 20.0 | - | - | - | - | - | - | - |
| 28 May | 08:45 | 16.0 | 18.0 | 0 | 0 | 0.5 | 0 | 7.6-8.2 | 179.0 | 196.9 |
| | 16:00 | - | 23.0 | - | - | - | - | - | - | - |
| 30 May | 08:15 | 11.0 | 13.5 | 0 | 0 | 0.5 | 0 | 7.6-8.0 | 179.0 | 143.2 |
| | 14:00 | - | 20.0 | - | - | - | - | - | - | - |
| 5 June | 16:30 | 18.0 | 15.0 | 0 | 0 | 0.5 | 0 | 8.8 | 143.2 | 161.1 |
| 11 June | 13:15 | 17.0 | 20.0 | 0-0.25 | 0 | 0.5 | 0 | 8.4 | 143.2 | 161.1 |
| 19 June | 09:00 | 14.0 | 15.0 | 0 | 0 | 0.5 | 0 | 8.2 | 143.2 | 125.3 |
| 25 June | 11:40 | 10.0 | 15.0 | 0 | 0 | 0.5 | 0 | 8.0 | 125.3 | 143.2 |
| | 16:00 | - | 18.0 | - | - | - | - | - | - | - |
| 2 July | 16:15 | 21.0 | 27.0 | 0 | 0 | 0.5 | 0 | 8.4 | 179.0 | 179.0 |
| 17 July | 14:30 | 15.0 | 20.0 | 0 | 0 | 0.5 | 0 | 7.8 | 196.9 | 179.0 |
| 23 July | 14:00 | 19.0 | 22.0 | 0 | 0 | 0.5 | 0 | 7.8 | 196.9 | 179.0 |
| 2 August | 12:00 | 15.0 | 18.0 | 0 | 0 | 0.5 | 0 | 8.2 | 179.0 | 214.8 |
| 9 August | 09:40 | 22.0 | 17.0 | 0 | 0 | 0.5 | 0 | 7.8 | 196.9 | <214.8 |
| 15 August | 09:00 | 20.0 | 18.0 | 0 | 0 | 0.5 | 0 | 7.8 | 214.8 | 179.0 |
| 22 August | 14:45 | 19.0 | 15.0 | 0 | 0 | 0.5 | 0 | 7.8 | <214.8 | 196.9 |

Water parameter test and increments (ppm): phosphate – 0, 0.25, 0.50, 1.00, 2.50, 5.00
nitrite – 0, 0.25, 0.50, 1.00, 2.50, 5.00
nitrate – 5, 10, 20, 50, 110;
ammonia – 0, 0.5-1.0, 2.0-3.0, 4.0-5.0, 6.0-7.0
pH – 6.0, 6.4, 6.6, 7.0, 7.2, 7.6 (high range) 7.4, 7.8, 8.0, 8.2, 8.4, 8.8

Appendix D. *continued*

**West Rearing Pond**

| Date (2001) | Time - 24 hour | Parameter | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | Air temperature (°C) | Water temperature (°C) | phosphate (ppm) | nitrite (ppm) | nitrate (ppm) | ammonia (ppm) | pH (ppm) | general hardness - GH (ppm) | Alkalinity - KH (ppm) |
| 2 May | 10:00 | - | 10.0 | 0 | 0 | 0.5 | 0 | 7.6-8.0 | 214.8 | 196.9 |
| 7 May | 8:30 | 12.0 | 10.0 | 0 | 0 | 0.5 | 0 | 7.6-8.2 | 179.0 | 196.9 |
| 9 May | 8:45 | 5.0 | 9.0 | 0 | 0 | 0.5 | 0 | 7.6-8.4 | 161.1 | 214.8 |
| 14 May | 8:30 | 13.0 | 13.5 | 0 | 0 | 0.5 | 0 | 7.6-8.8 | 161.1 | 161.1 |
| 16 May | 8:00 | 9.0 | 12.0 | 0 | 0 | 0.5 | 0 | 7.6-8.4 | 143.2 | 161.1 |
| 23 May | 8:45 | 17.0 | 18.0 | 0 | 0 | 0.5 | 0 | 7.6-8.4 | 143.2 | 161.1 |
| | 15:45 | - | 24.0 | - | - | - | - | - | - | - |
| 24 May | 8:00 | - | 16.0 | - | - | - | - | - | - | - |
| | 16:00 | - | 23.0 | - | - | - | - | - | - | - |
| 25 May | 8:00 | - | 14.0 | - | - | - | - | - | - | - |
| | 16:00 | - | 20.0 | - | - | - | - | - | - | - |
| 28 May | 8:45 | 16.0 | 17.0 | 0 | 0 | 0.5 | 0 | 7.6-8.8 | 143.2 | 143.2 |
| | 16:00 | - | 23.0 | - | - | - | - | - | - | - |
| 30 May | 8:15 | 9.5 | 13.0 | 0 | 0 | 0.5 | 0 | 7.6-8.4 | 179.0 | 214.8 |
| | 14:00 | - | 21.0 | - | - | - | - | - | - | - |
| 5 June | 17:00 | 14.0 | 16.0 | 0 | 0 | 0.5 | 0 | 8.8 | 179.0 | 196.9 |
| 11 June | 13:15 | 17.0 | 14.5 | 0 | 0 | 0.5 | 0 | 8.2 | 179.0 | 161.1 |
| 19 June | 8:53 | 14.0 | 13.0 | 0 | 0 | 0.5 | 0 | 8.4 | 161.1 | 143.2 |
| 25 June | 11:20 | 10.0 | 14.0 | 0 | 0 | 0.5 | 0 | 8.4 | 161.1 | 179.0 |
| | 16:00 | - | 18.0 | - | - | - | - | - | - | - |
| 2 July | 16:33 | 21.0 | 24.0 | 0 | 0 | 0.5 | 0 | 8.4 | 214.8 | 196.9 |
| 17 July | 14:30 | 15.0 | 20.0 | 0 | 0 | 0.5 | 0 | 8.0 | <214.8 | 214.8 |
| 23 July | 14:00 | 19.0 | 21.0 | 0 | 0 | 0.5 | 0 | 8.2 | <214.8 | <214.8 |
| 2 August | 12:00 | 15.0 | 16.0 | 0 | 0 | 0.5 | 0 | 8.0 | <214.8 | <214.8 |
| 9 August | 9:40 | 22.0 | 14.5 | 0 | 0 | 0.5 | 0 | 7.4 | <214.8 | 196.9 |
| 15 August | 9:00 | 20.0 | 16.0 | 0 | 0 | 0.5 | 0 | 7.8 | 214.8 | <214.8 |
| 22 August | 14:45 | 19.0 | 15.5 | 0 | 0 | 0.5 | 0 | 8.0 | 214.8 | 161.1 |

Water parameter test and increments (ppm): phosphate – 0, 0.25, 0.50, 1.00, 2.50, 5.00
nitrite – 0, 0.25, 0.50, 1.00, 2.50, 5.00
nitrate – 5, 10, 20, 50, 110
ammonia – 0, 0.5-1.0, 2.0-3.0, 4.0-5.0, 6.0-7.0
pH – 6.0, 6.4, 6.6, 7.0, 7.2, 7.6 (high range) 7.4, 7.8, 8.0, 8.2, 8.4, 8.8

Appendix E. Number of frogs captured from the west and east-rearing pond, color each was marked and site at which they were released.

| **Date** | **Number of Frogs Collected** | | **Color Marked** | **Total Released** | | | |
|---|---|---|---|---|---|---|---|
| | **East** | **West** | | **Cooling Pond-** Release Site 1 | **Oxbow-** Release Site 2 | **North Sask. River-** Release Site 1 | **East Rearing Pond** |
| 01 August | 180 | - | Blue | - | 180 | - | - |
| 03 August | 320 | - | Blue | - | 320 | - | - |
| 07 August | 400 | - | Blue | - | 400 | - | - |
| 10 August | 400 | 280 | Red | 680 | - | - | - |
| 10 August | - | 180 | Red | - | - | 180 | - |
| 13 August | 107 | 100 | Blue | - | 270 | - | - |
| 13 August | 130 | 20 | Red | - | 150 | - | - |
| 16 August | 43 | - | Blue | - | 43 | - | - |
| 16 August | 20 | - | Red | 20 | - | - | - |
| 16 August | 170 | - | Red | - | - | 170 | - |
| 24 August | - | 400 | Red | - | - | 400 | - |
| 31 August | 75 | 75 | Yellow | - | - | - | 150 |
| 31 August | 83 | - | Red | 83 | - | - | - |
| TOTAL | 1928 | 1055 | TOTAL | 783 | 1300 | 750 | 150 |
| GRAND TOTAL | 2983 | | GRAND TOTAL | 2983 | | | |

Appendix F. Specific information on each leopard frog observation made at the Raven River release site study area in 2001.

| Frog | Sex | Mark | Observed / Captured | Date* (2001) | Weight (g) | SVL (mm) | Frog Colour | Notes |
|---|---|---|---|---|---|---|---|---|
| 1 | M | No Mark | Captured | 19 June | 11.0 | 46.0 | Green | Observed in east rearing pond, believed to have been captive reared and released in 2000. Dorsal pattern sketched. This frog remained in the east rearing pond until its release into the cooling pond on 24 August. This frogs was also heard calling from the east pond at approximately 17:00 on 2 August. |
| | | | Captured | 1 August | 33.0 | 73.0 | | |
| | | | Captured | 24 August | ? | ? | | |
| 2 | ? | Orange / Left hind foot | Captured | 19 June | 7.5 | 42.0 | Brown | Observed in small pond near the Raven River at the oxbow release site. It is believed that the frog (Frog 1) observed on 19 June and 12 July is one of the same. Upon first observation it could not be determined if it was male or female because of its small size. Unfortunately it was not sexed on its second capture. |
| | | | Captured | 12 July | 14.5 | 50.0 | | |
| 3 | ? | ? | Observed | 19 June | NA | NA | Green | Observed in small pond as frog number 2, but could not be captured on either observation date. This frog looked robust and healthy and was described as slightly larger than frog number 2 on 19 June. It is believed that the frog (Frog 3) observed on 19 June and 12 July is one of the same. |
| | | | Observed | 12 July | NA | NA | | |
| 4 | ? | Orange / Left hind foot | Captured | 12 July | 20.0 | 50.0 | Green | This frog was observed and captured at the oxbow release site in one of the larger oxbows. It was not sexed. |
| 5 | ? | Orange / Left hind foot | Captured | 12 July | 15.0 | 53.0 | Brown | This frog was observed and captured at the oxbow release site in one of the larger oxbows. It was not sexed. |
| 6 | ? | ? | Observed | 12 July | NA | NA | Brown | Observed at the oxbow release site in one of the larger oxbows. |
| 7 | ? | ? | Observed | 12 July | NA | NA | Brown | Observed at the oxbow release site in one of the larger oxbows. |

M = Male, F = Female, SVL = Snout to vent length (body length), * (Date) = Date of observation or capture

Appendix F. *continued*

| Frog | Sex | Mark | Observed / Captured | Date* (2001) | Weight (g) | SVL (mm) | Frog Colour | Notes |
|---|---|---|---|---|---|---|---|---|
| 8 | ? | No Mark | Captured | 12 July | 17.0 | 49.5 | Green | Observed at the oxbow release site in one of the larger oxbows. |
| 9 | F | Green / Left hind foot | Observed | 17 July | NA | NA | Brown | This frog was first observed in the east rearing pond on 25 June. On 17 July the frog relocated to the west rearing pond. The frog was captured for the first time on 25 July and remained in the west pond until its release into the cooling pond on 31 August. |
| | | | Captured | 25 July | 17.0 | 52.0 | | |
| | | | Captured | 31 August | 36.0 | 64.0 | | |
| 10 | M | No Mark | Observed | 10 August | NA | NA | Green | This frog was first observed on 10 August in the east rearing pond but it is suspected that this same frog was heard calling from the cooling pond on 2 August. On 13 August Frog 10 was captured for the first time. Frog 10 remained in the east pond until its release into the cooling pond on 24 August. |
| | | | Captured | 13 August | 43.0 | 70.0 | | |
| | | | Captured | 24 August | ? | ? | | |
| 11 | ? | ? | Observed | 7 August | NA | NA | Green | Observed at oxbow release site in small pond that was formerly an old buffalo wallow. |
| 12 | ? | Yellow / Left hind foot | Observed | 14 August | NA | NA | Green | Observed at oxbow release site along Raven River. |
| 13 | F | Yellow / Left hind foot | Captured | 14 August | NA | NA | Brown | Observed at oxbow release site along Raven River. Was captured but SVL and weight not taken. |

M = Male, F = Female, SVL = Snout to vent length (body length), * (Date) = Date of observation or capture

Appendix G. Evaluation of potential leopard frog release sites investigated in 2001.

| | Site Name | Ownership | Advantages | Drawbacks |
|---|---|---|---|---|
| 1 | Gaetz Lakes | Municipal Nature Reserve - Bird Sanctuary (City of Red Deer) | Long-term protection and conservation of the site; education and public involvement opportunities (i.e. monitoring); quality breeding and summer habitat present at site; historic records associated with the Gaetz Lakes sanctuary. | Limited dispersal opportunities in the immediate vicinity of the Red Deer River; absence of quality over-wintering habitat in immediate area, although the gravel pits north of the oxbows may show some promise; limited migration routes/corridors between potential over-wintering habitat and breeding / summer habitats. |
| 2 | The Narrows (Provincial Recreation Area) | Private / Crown | Good access for frog release and monitoring; some public exposure possibilities at site; site secure (recreation area); presence of summer habitat; historic records associated with Buffalo Lake and area; stabilized lake levels; good dispersal opportunities within the Buffalo Lake area and to the Red Deer River via Tail Creek. | Poor over-wintering habitat in immediate area tested (The Narrows), however dissolved oxygen levels may be higher in the main lake compartment; breeding habitat in area surveyed was restricted to the main lake compartment (i.e. no separate, shallow, waterbody identified). |
| 3 | Hummer Project - Middle Wooden Lake (DU Project) | Ducks Unlimited Canada | Excellent upland summer habitat and presence of shallow bays for breeding; long-term protection and conservation of the site; good road and foot access; potentially good over-wintering habitat in main lake (springs located on lakeshore); good dispersal opportunities with neighbouring wetlands and possibly along Ghostpine Creek; site located in the central Parkland and considerable distance from known leopard frog populations. | Although Middle Wooden Lake is apart of a greater system of lakes and wetlands, dispersal opportunities may be limited. The site is part of the Ghostpine Creek drainage, which drains into the Red Deer River near Drumheller; Ghostpine Creek confluence with the Red Deer River is located in a region that is currently occupied by leopard frogs (i.e. little contribution of frogs along the upper headwaters of the Red Deer River). |
| 4 | Bigelow Reservoir Project (Buck for Wildlife Project / DU Project) | Crown | Long-term protection and conservation of the site; some public promotional possibilities at site; dispersal opportunities along Threehills Creek; suitable upland summer habitat; potential over-wintering habitat in main reservoir and behind water control structures at site. | Breeding habitat may be restricted to larger waterbodies within complex (i.e. bays and sheltered, shallow areas along shoreline); Threehills creek's confluence with the Red Deer River is located near Drumheller a region presently occupied by leopard frogs. |
| 5 | Great West Project (DU Project) | Ducks Unlimited Canada | Excellent upland summer habitat and breeding habitat; long-term protection and conservation of site. | Poor dispersal opportunities into major drainage systems; over-wintering habitat at this site may be completely absent; relatively poor access to site. |

Appendix G. *continued*

| | Site Name | Ownership | Advantages | Drawbacks |
|---|---|---|---|---|
| 6 | B & E Project (DU Project) | Ducks Unlimited Canada | Long-term protection and conservation of the site. | Poor dispersal opportunities into major drainage systems (i.e. the Red Deer River). |
| 7 | Cassidy Project - Mud Lake (DU Project) | Ducks Unlimited Canada / Private | Approximately one-half of Mud Lake and a number of semi-permanent and permanent wetlands are managed by Ducks Unlimited; good potential over-wintering habitat in Mud Lake; good upland summer habitat at the site; presence of breeding habitat. | Relatively poor access to site; dispersal opportunities into major drainages, including Red Deer River, are limited. |
| 8 | WIK Project - Ghostpine Creek (DU Project) | Ducks Unlimited Canada | Long-term protection and conservation of the site; good upland summer habitat; good road and foot access to site. | Potential breeding and over-wintering habitat at the site was non-existent during time of survey because of dry conditions. |
| 9 | Big Valley Creek Project (DU Project) | Ducks Unlimited Canada | Excellent upland summer habitat and breeding habitats present; some degree of long-term protection and conservation; potential dispersal into the Red Deer River via Big Valley Creek. | Suitable over-wintering habitat may not exist at this site. |
| 10 | Tail Creek | Private | Historic leopard frog record associated with the site; breeding and summer habitat present at the site; possible over-wintering habitat present in the Red Deer River or large beaver ponds in area; excellent dispersal opportunity into the Red Deer River; local campground near site may offer some public promotion and education opportunities at the site. | Roads and a large mowed lawn area heavily fragment migration routes and possible summer habitat. |

Appendix G. *continued*

| | Site Name | Ownership | Advantages | Drawbacks |
|---|---|---|---|---|
| 11 | Open Creek Reservoir | Crown | Good road access to site; long-term protection and conservation of the site; public education and promotional opportunities present; potentially good over-wintering habitat in area (lake); dispersal opportunities into the headwaters of the Red Deer River via Open Creek and the Medicine River. | Upland habitat heavily forested in area surveyed – poor summer habitat; absence of shallow wetlands in area for breeding purposes; site is considerable distance from the Red Deer River via the Medicine River. |
| 12 | Beaver Lake (Buck for Wildlife Project) | Crown | Historic leopard frog records in local area (i.e. Beaver Creek, Raven River and the Raven Brood Trout Station); good public access; promotional opportunities at the site; potentially good over-wintering habitat in lake (lake aerated). | Lake is stocked with Rainbow Trout; breeding habitat immediately associated with the lake is minimal; upland habitat consists primarily of thick conifer forest - poor summer habitat; dispersal opportunities along beaver creek may be minimal. |
| 13 | Wommacks Lakes | Private | In general, this site exhibited excellent amphibian habitat; good breeding, summer and potential over-wintering habitat present; local landowner co-operation. | Dispersal opportunities out of the Wommacks Lakes area are limited and restricted to inconsistent tributaries of Beaver Creek. |
| 14 | North Raven River (Buck for Wildlife Project) | Crown / Private | Much of the North River is fenced by Buck for Wildlife; many stretches of the river may offer suitable over-wintering habitat; good dispersal opportunities to Raven River and headwaters of the Red Deer River; good upland habitat along much of the river. | Road access is mainly limited to bridge crossings; lack of standing, shallow water along system for breeding; only a few beaver dams and backwaters, which could be used for breeding, were identified during 2001 surveys. |
| 15 | Battle River (Big Knife Provincial Park) | Alberta Provincial Park | Long-term protection and conservation at the site; public education and promotional opportunities; good road and foot access to release frogs and monitor frogs; potential over-wintering habitat associated with the Battle River; presence of quality summer habitat and breeding habitat; dispersal opportunities along the Battle River. | Confluence of the Battle River and North Saskatchewan River occur outside of Alberta (Saskatchewan); leopard frogs *may* be present in the Battle River drainage near the Wainwright Region? |

Appendix G. *continued*

| | Site Name | Ownership | Advantages | Drawbacks |
|---|---|---|---|---|
| 16 | Battle Lake | County Campground / Private / Crown | Good road and foot access; potential suitable over-wintering habitat in lake and upper headwaters of the Battle River. | Poor summer and breeding habitat in area surveyed (surrounding Battle Lake). |
| 17 | Rocky Mountain House National Historic Site | Parks Canada | Long-term protection and conservation at the site; high education and public involvement with project through existing infrastructure; historic leopard frog records occur in the region; excellent breeding and summer habitat; dispersal possibilities along North Saskatchewan River. | Over-wintering habitat may be limited at site (beaver pond or North Saskatchewan River); dispersal opportunities in the immediate area are limited; if a population was established at this site it may be restricted to the immediate area of release. |
| 18 | Buster Creek | Provincial Park / Crown / Private | Sections of Buster Creek in Crimson Lake Provincial Park are protected; Buster Creek may offer good over-wintering conditions; public education and promotion opportunities possible. | Poor access to the creek in general; no suitable breeding habitat was identified along Buster Creek and summer habitat was limited to the floodplain at the confluence with the North Saskatchewan River. |
| 19 | Crimson Lake (Crimson Lake Provincial Park) | Alberta Provincial Park | Lake may be offer suitable over-wintering habitat; public access, education and promotion opportunities possible; long-term protection and conservation of the site. | Limited summer habitat and breeding habitat present in area. |
| 20 | North Saskatchewan River (Beaver Pond) | Private Land | Supportive landowners in area and at the site; excellent dispersal opportunities from release site and along the river and additional wetlands; excellent summer habitat throughout area; diversity of breeding habitat and over-wintering habitat possibilities in the area, including beaver ponds, backwaters, oxbows and spring fed wetlands. | Wet weather and winter access to site may be poor. |

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